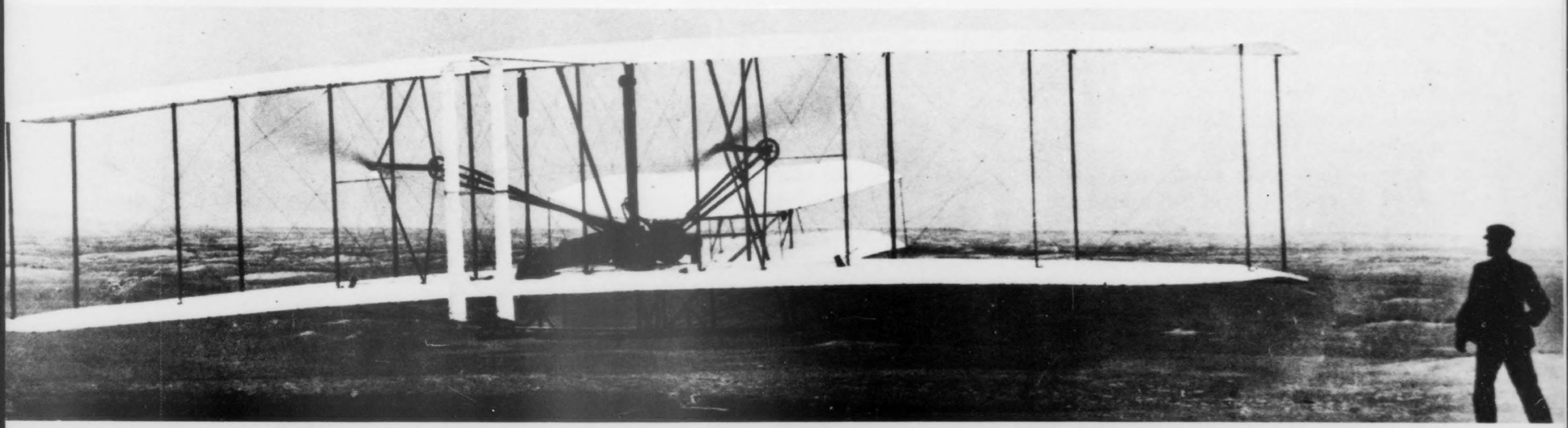
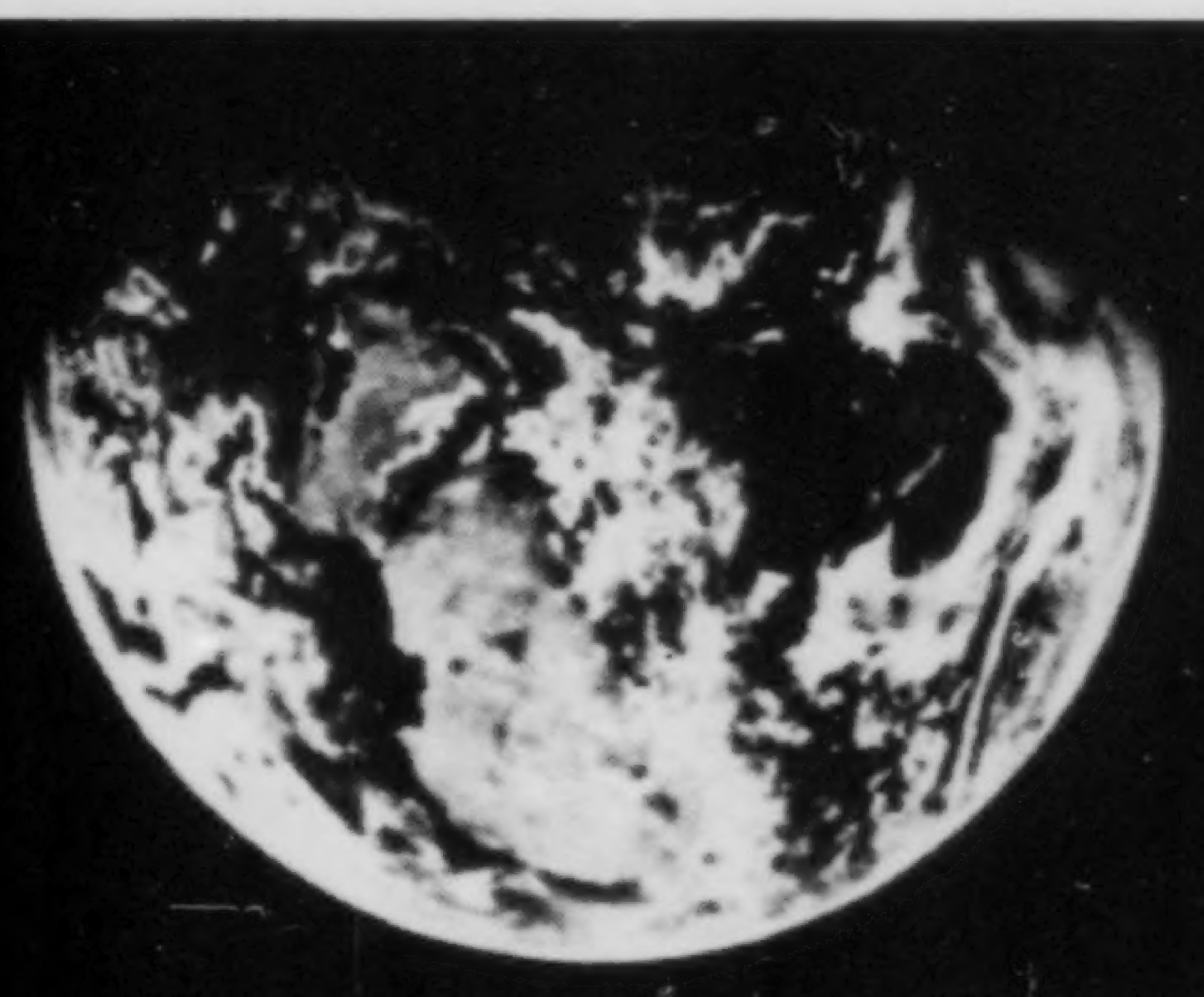
Air & Space

National Air & Space Museum
Smithsonian Institution

Vol. No. 1 March 1978





From the National Air and Space Museum

A New Publication for Educators

This new mini-magazine, sent to educators on request at no charge, combines information from many sources for a condensed overview of what is happening in the use of the entire expanse above Earth's surface. These developments affect many kinds of study and open new careers for those who are students today.

In the past 75 years, aviation has advanced from the first powered vehicle, that covered 120 feet in 12 seconds (the Wright brothers' "Flyer," top, above) to military and civilian craft flying faster than sound.

In the past 20 years, engineers have developed vehicles of even greater power, sufficient to break the hold of gravity and hurl objects completely out of the atmosphere. Some orbit close by, serving interests on the ground, and rousing new questions about the proper use of the "eyes" and "ears" overhead. Other spacecraft have gone farther, some carrying men, safely, into a lethal environment. Their photographs of Earth, like the one above, have stirred millions of people to a new feeling about this planet.

The National Air and Space Museum wishes to share its resources with educators and be responsive to the readers of this new publication.

INSIDE: Model of Shuttle to make, Page 6. **Will the speed of light always be a barrier? Page 9.**

Sharing —

Materials from the National Air and Space Museum

Pre-Visit Plans

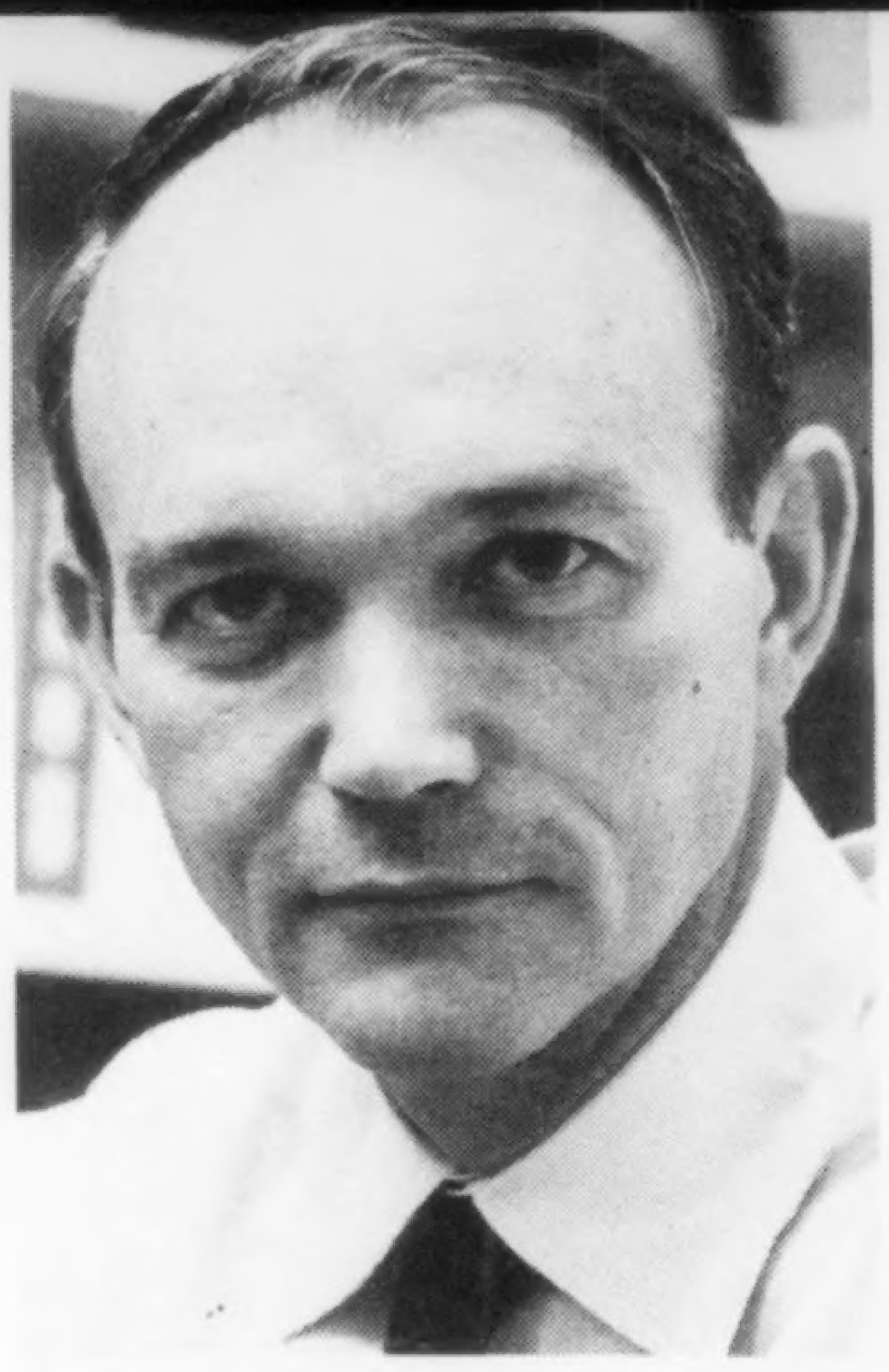
These are packets of materials sent to teachers in the Washington area before they bring classes to the Museum. The text suggests special areas of study to complement the Museum visit, and includes discussion questions which could be useful to teachers elsewhere, possibly in connection with class visits to other museums with aerospace exhibits.

Discovery, for K-3, points out basic differences between aircraft and spacecraft. *Moon Journeys,* for 4-6, adapts scientific findings about the nature of the Moon. *History of Flight,* for 4-6, traces developments from early glider and balloons to present day vehicles. *Flight in the Arts,* for 4-6, suggests projects for an art class. All free on request to Education Officer, Room 3568, National Air and Space Museum, Smithsonian Institution, Washington DC 20560.

Museum Guide for the Handicapped

Museums and Handicapped Students—Guidelines for Educators is the culmination of an 18 month study of museum programs and services for deaf, blind and physically handicapped visitors; soft cover, 6 by 9 in., 200 pp., illus., published by the National Air and Space Museum under a grant from the Department of Health, Education and Welfare. Free on request to Harold Snider, Coordinator, Programs for the Handicapped, Room 3566 (Museum address above).

Briefing From the Director



Michael Collins

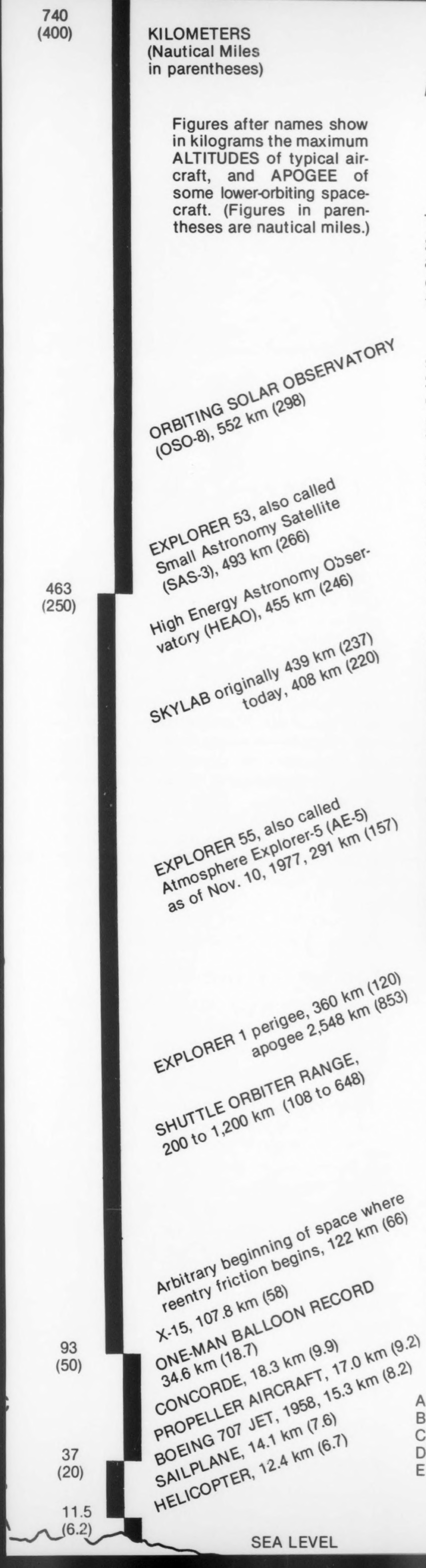
Welcome to the National Air and Space Museum! This publication is intended to make you, our readers, part of our Museum family. We want to share with you some of the exciting things going on today in air and space, not only here in the Museum, but around the country and the world—and even beyond.

Our surveys show that young people are keenly interested in the Museum. They want to know more about our heritage in air and space, and they want to know how they personally can participate in future developments. We hope to present information of this kind in a form that educators can readily use. I would appreciate hearing from you. What kind of information would you like? What do you feel you are missing that would help you in your classroom work?

I realize that there is a tremendous amount of reading material available today, but in a high technology field such as air and space, it is sometimes difficult to digest or evaluate events as they ever more swiftly unfold. For example, it took 120 years for us to progress from balloon flight to heavier-than-air craft (1783-1903). In less than half that interval (54 years) Sputnik arrived. Only 12 years after Sputnik, man landed on the Moon. What next? It's a bewildering time for all of us, but it must be especially so for inquisitive students.

In this Museum, our staff has tried very hard to design exhibits which describe past events accurately, and speculate about future ones intelligently. I know that a lot of you (15,000,000) have visited us since we opened on July 1, 1976. For you, perhaps this mini-magazine will contain information to update your visit. For those who haven't had a chance to come to Washington, I hope it will serve as a temporary substitute for a visit, and will be helpful to you in making the magic world of air and space more accessible to your students. Once again, welcome to the National Air and Space Museum.

Left, the National Air and Space Museum. Exhibits include actual history-making vehicles, such as the X-15 photographed below in the 1950s during a launch from a B-52; it often soared into space.


740 (400)
463 (250)
93 (50)
37 (20)
11.5 (6.2)
ORBITING SOLAR OBSERVATORY (OSO-8), 552 km (298)
EXPLORER 53, also called Small Astronomy Satellite (SAS-3), 493 km (266)
High Energy Astronomy Observatory (HEAO), 455 km (246)
SKYLAB originally 439 km (237) today, 408 km (220)
EXPLORER 55, also called Atmosphere Explorer-5 (AE-5) as of Nov. 10, 1977, 291 km (157)
EXPLORER 1 perigee, 360 km (120) apogee 2,548 km (853)
SHUTTLE ORBITER RANGE, 200 to 1,200 km (108 to 648)
Arbitrary beginning of space where reentry friction begins, 122 km (66)
X-15, 107.8 km (58)
ONE-MAN BALLOON RECORD 34.6 km (18.7)
CONCORDE, 18.3 km (9.9)
PROPELLER AIRCRAFT, 17.0 km (9.2)
BOEING 707 JET, 1958, 15.3 km (8.2)
SAILPLANE, 14.1 km (7.6)
HELICOPTER, 12.4 km (6.7)
SEA LEVEL
A — Troposphere
B — Stratosphere
C — Mesosphere
D — Ionosphere
E — Exosphere

KILOMETERS
(Nautical Miles
in parentheses)

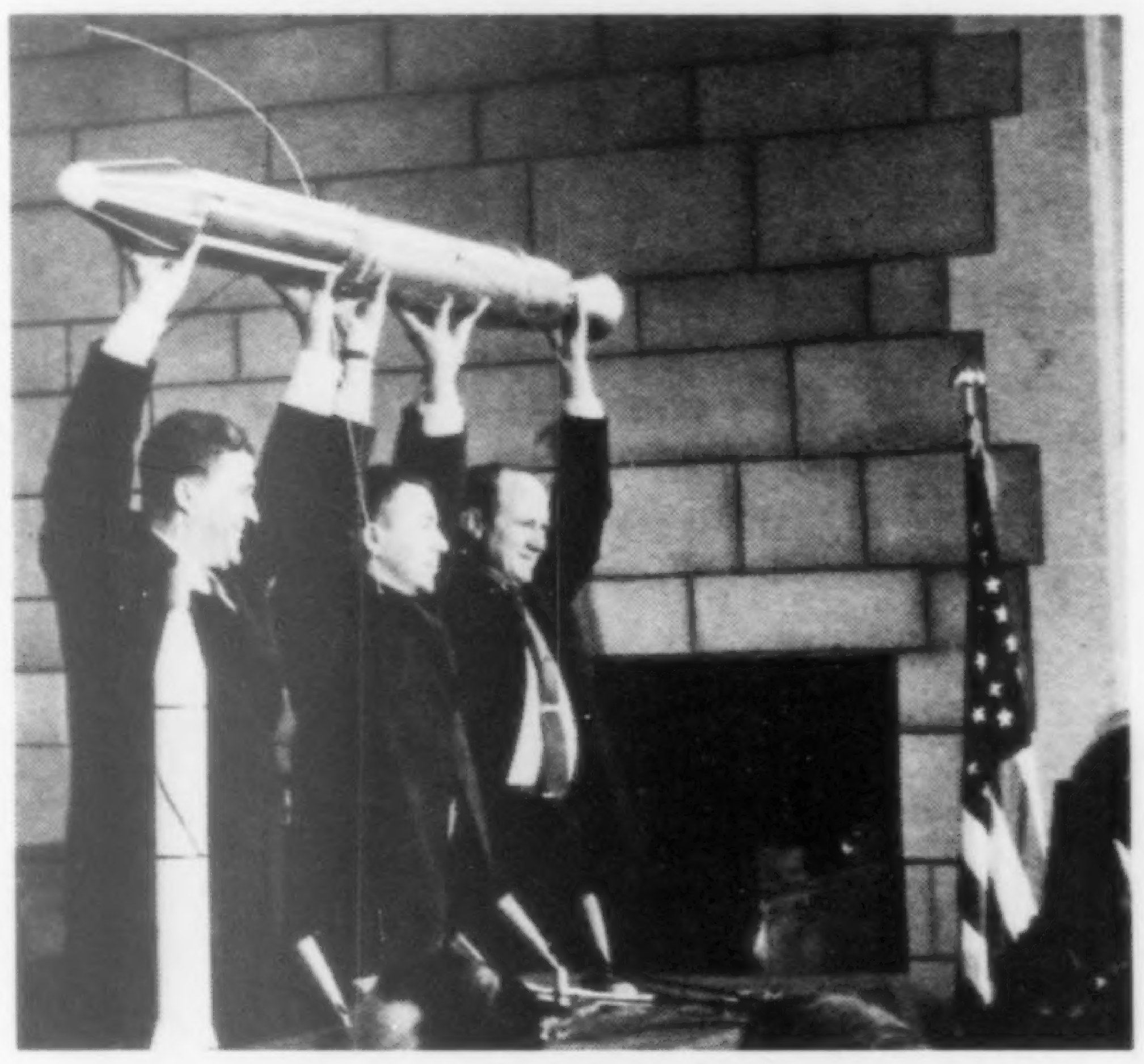
Figures after names show in kilograms the maximum ALTITUDES of typical aircraft, and APOGEE of some lower-orbiting spacecraft. (Figures in parentheses are nautical miles.)

EXPLORER 1 —

A First for Science, Too

The beginning of the U.S. space program and of scientific probing of space, are described by Tom Crouch, Associate Curator, Department of Astronautics, National Air and Space Museum:

This first American artificial Earth satellite was preceded into orbit by the Soviet spacecraft Sputniks I and II. Coupled with the spectacular launch pad failure of the U.S. Vanguard Test Vehicle 3 on December 6, 1957, the Soviet triumph led many observers to doubt continued U.S. leadership in science and technology. The accelerated American space program that culminated in the manned lunar landings of the Apollo program was, in large measure, part of an effort to recoup the loss to American prestige. The success of Explorer 1 was the first step in this process.



Left to right, Dr. Wernher von Braun, Dr. James Van Allen and Dr. William Pickering displayed a model of Explorer 1 at a press conference after the successful launch in 1958.

The instruments on board the satellite, designed to measure radiation levels, temperature and micro-meteorite impacts, were prepared by Dr. James Van Allen, then of the State University of Iowa. The Jupiter-C launch vehicle, a modified Redstone ballistic missile, was the product of an engineering team headed by Dr. Wernher von Braun at the Army's Redstone Arsenal in Huntsville, Alabama. Dr. William Pickering, Director of the Jet Propulsion Laboratory of the California Institute of Technology, coordinated the project.

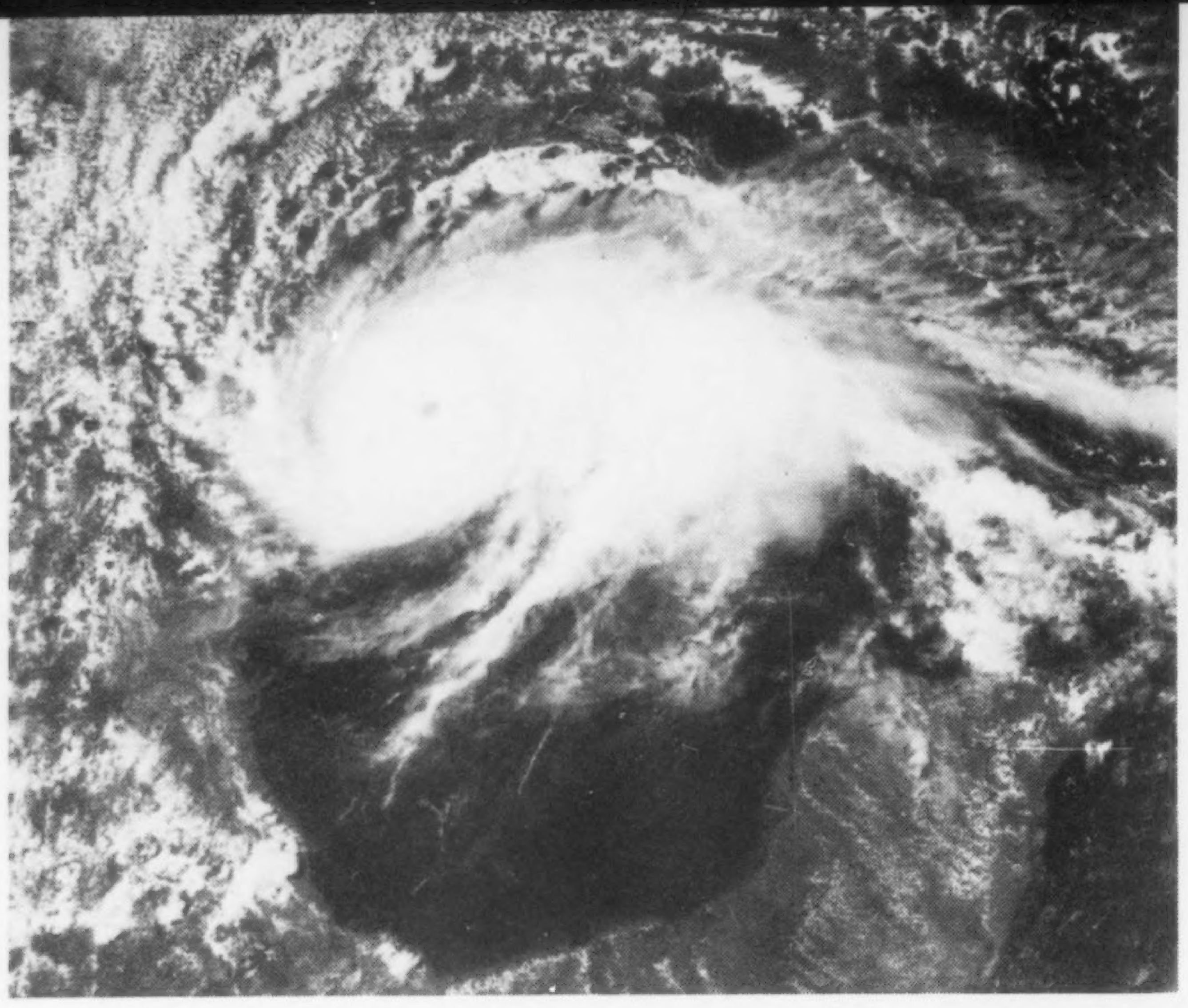
While Explorer 1 was a reasonably uncomplicated vehicle when compared to the more sophisticated unmanned spacecraft that have followed, it was responsible for the most fundamentally important discovery of the early years of space exploration—the Van Allen radiation Belts. Confirmed and amplified by later Explorer and Pioneer spacecraft, the data from Explorer 1 provided a clear demonstration of the scientific potential of the Earth satellite.

From ground level observatories, scientists deduce much about Earth's outer environment, but the atmosphere blocks many wavelengths. Aircraft take instruments above most atmospheric vapor for better optical viewing; last year it was from NASA's Kuiper Airborne Observatory that rings around Uranus, like those of Saturn, were first detected. Instruments launched beyond the atmosphere catch the full flow of X-rays, gamma rays and cosmic rays streaming in from the Sun and universe, and relay data on many other invisible conditions which affect Earth and astronauts in space. Astronomers now see an unaccountably violent universe. Spacecraft flying by Mercury, Venus, Jupiter (Saturn in 1979), the manned lunar landings and the unmanned Mars landings have all returned data to help in understanding this home planet.

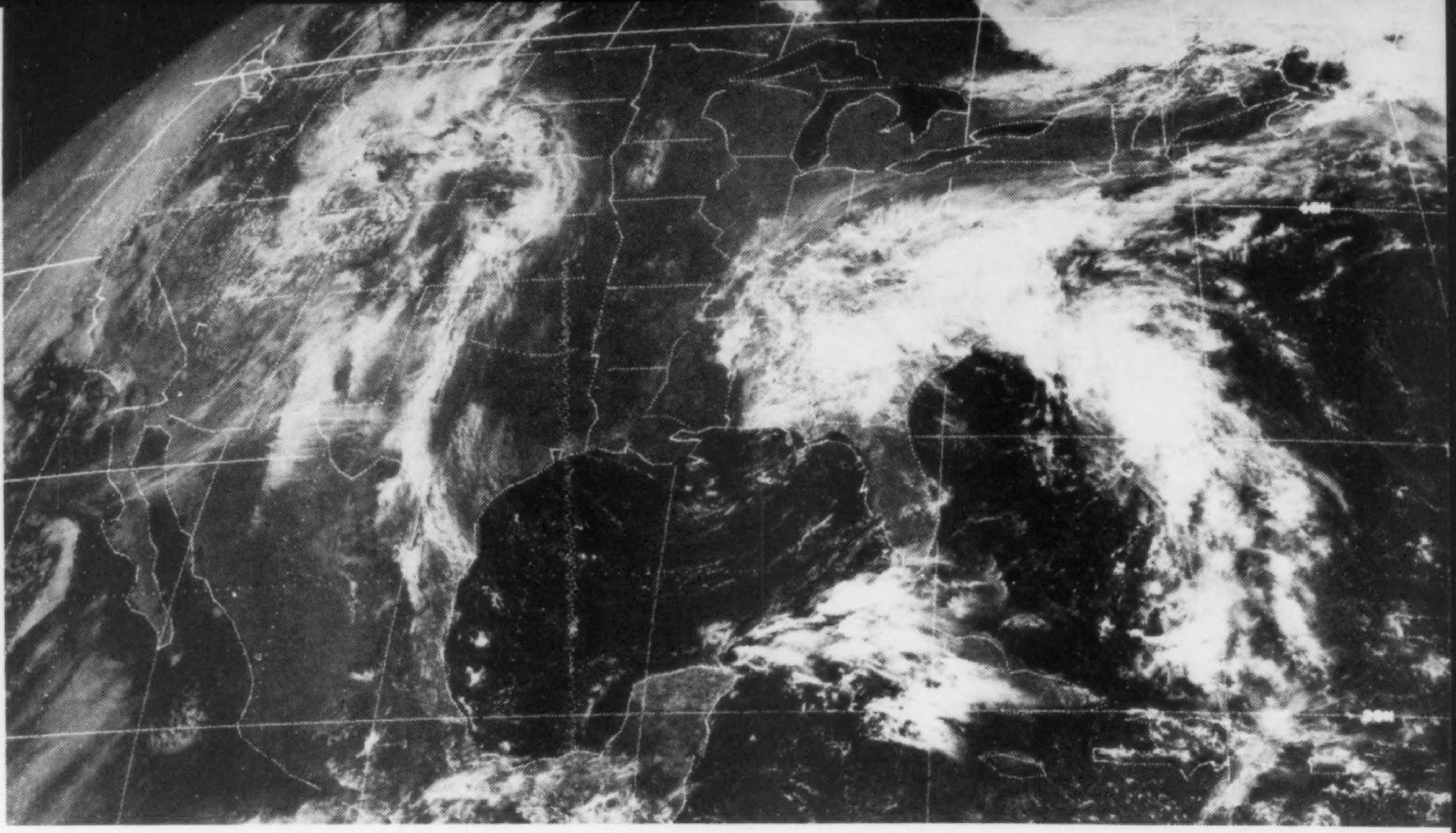
How far do spacecraft range, collecting scientific information? The line to the left, 11 inches long, represents 740 kilometers. Names of aircraft are not set in to scale. Names of some nearby satellites are placed according to apogee. How much farther would the line have to be extended to show, on the same scale, the distance of satellites whose orbit-speed matches that of Earth's rotation so that they appear stationary? What extension, on the same scale, to the Moon, and to Pioneer 10 which still sends back data on its course out of the solar system?

	Mean Distance	Length of line on same scale
Geostationary satellites		
	35,700 km	**13 m (44 ft)**
Moon	**386,232 km**	**146 m (478 ft)**
Pioneer 10	**12 AU***	**677 km (421 mi)**

*** One Astronomical Unit (AU) is 93 million miles.**



1 September 1977



25 May 1977

EARTH-OBSERVING SATELLITES —

New Tools for Global Management

Some teachers may want to ask their students to make a list: What would they look for on the Earth's surface if they were astronauts in a space station at the altitude which would keep them moving at the same rate as Earth's rotation? They would always be observing the same territory, almost all of North and South America. They would have special magnifying glasses so that they could distinguish clouds, mountains, and features larger than about half a mile square.

They could watch the changing shapes and speeds of clouds, estimate wind strength, and with other sensors get a reading of temperatures. They are well on their way to forecasting weather for the two continents.

How important is it to have a worldwide view of developing weather? As it happens, five almost identical meteorological satellites are being positioned around the world, two by the U.S., one each by Japan, the U.S.S.R. and the European Space Agency; the nations will share data. An international group of scientists starts the first Global Atmospheric Research Program test this year.

After the National Aeronautics and Space Administration (NASA) pioneered the technology of weather satellites in the early 1960s, a permanent system was quickly authorized and added to the resources of weather experts in the Department of Commerce. They operate spacecraft in two kinds of orbits. One is the steady-view type which the class has just been imitating; it is called GOES for Geostationary Operational Environmental Satellite. The views above are from GOES. A computer dots in the outlines of states. Since images are produced every half hour, the course of a hurricane (above left) can be monitored and its dangers forecast.

Other weather satellites may be imagined in this way: The class is in a spacecraft orbiting Earth over the Poles. These passengers can also see larger details on Earth's surface. Earth is rotating beneath while they circle around it. They see a curving swath from the North Pole almost to the South Pole. On the next circuit, they are seeing a swath just to the west of the first. Each orbit presents another strip until, after nine days, they are back where they started. They look down at the first place, again, at the same time of day, in the same lighting. If there are changes, they are probably real and not tricks of different lighting. What is the value of such repetitive viewing, every ninth day, for years? The present polar orbiters are called Nimbus 6 and NOAA-5 (for the managing agency, the National Oceanic and Atmospheric Administration).

Telephones for the World

More people can telephone each other more easily, now, because of the internationally owned system diagrammed to the right. Geostationary satellites at three locations over the equator can switch telephone calls, TV and data transmission between any points within their field of view; Earth stations are at the ends of the radiating lines. London, Madrid or Rome can be connected to Peking via the Indian Ocean satellite. A New Yorker can reach Peking because his call is flashed by a domestic U.S. communications satellite to the west coast where it is sent up to the Pacific Ocean INTELSAT unit.

"INTELSAT works better than the United Nations," said a spokesman at the office of the U.S. member, COMSAT. "Why?" "Because the 98 nations that own the system invested money and are making a profit."

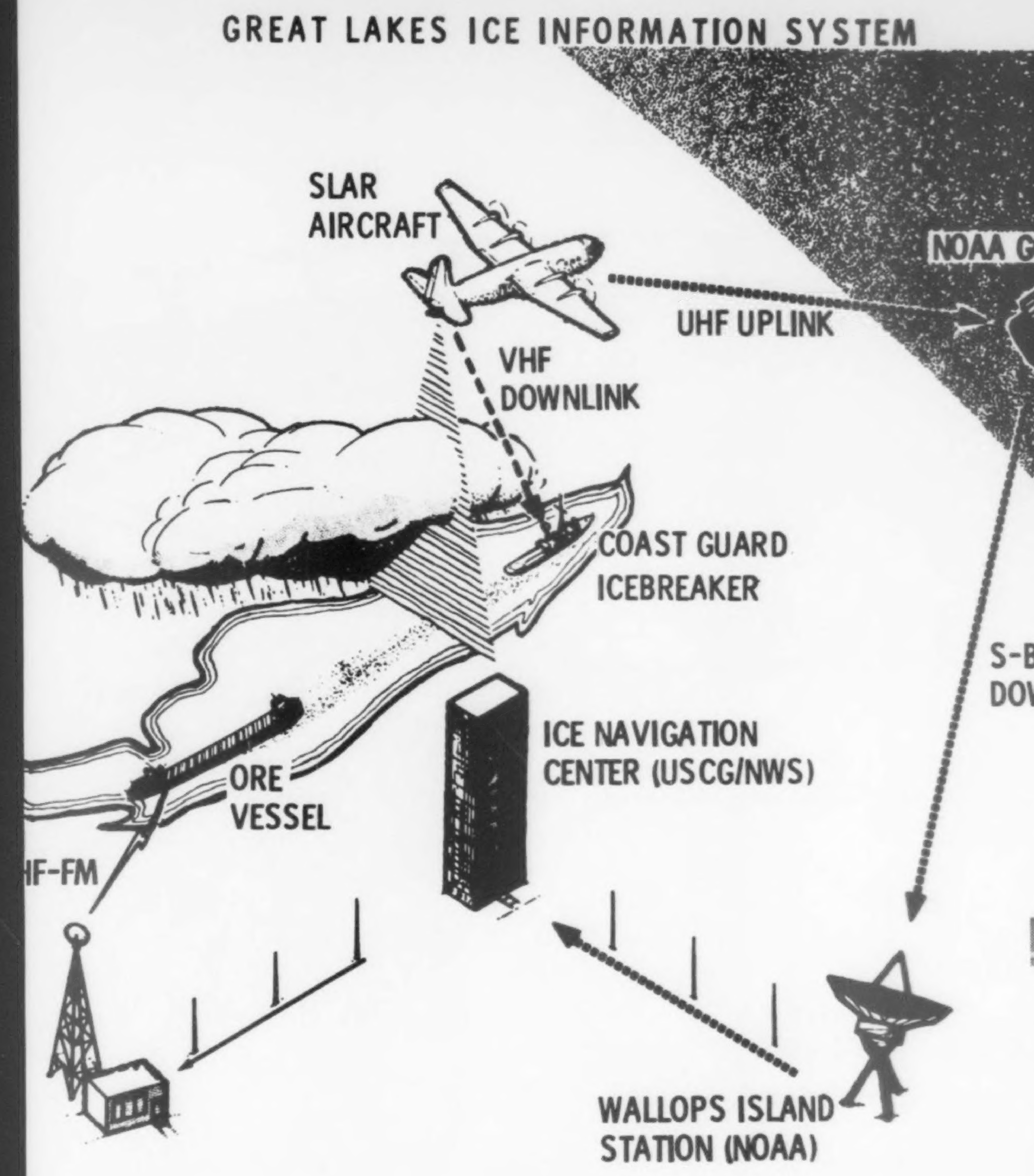
A subsidiary of COMSAT operates three MARISAT for static-free ship-to-shore communications throughout the world, by vessels of many nations. Six U.S. domestic communications satellites are now working. Five experimental ones (four in the ATS group, and the U.S.-Canadian CTS) have demonstrated two-way audio-video links in education, business conferencing, and medical aid for remote areas. Two OSCAR satellites built by amateurs are used by radio "hams" throughout the world.

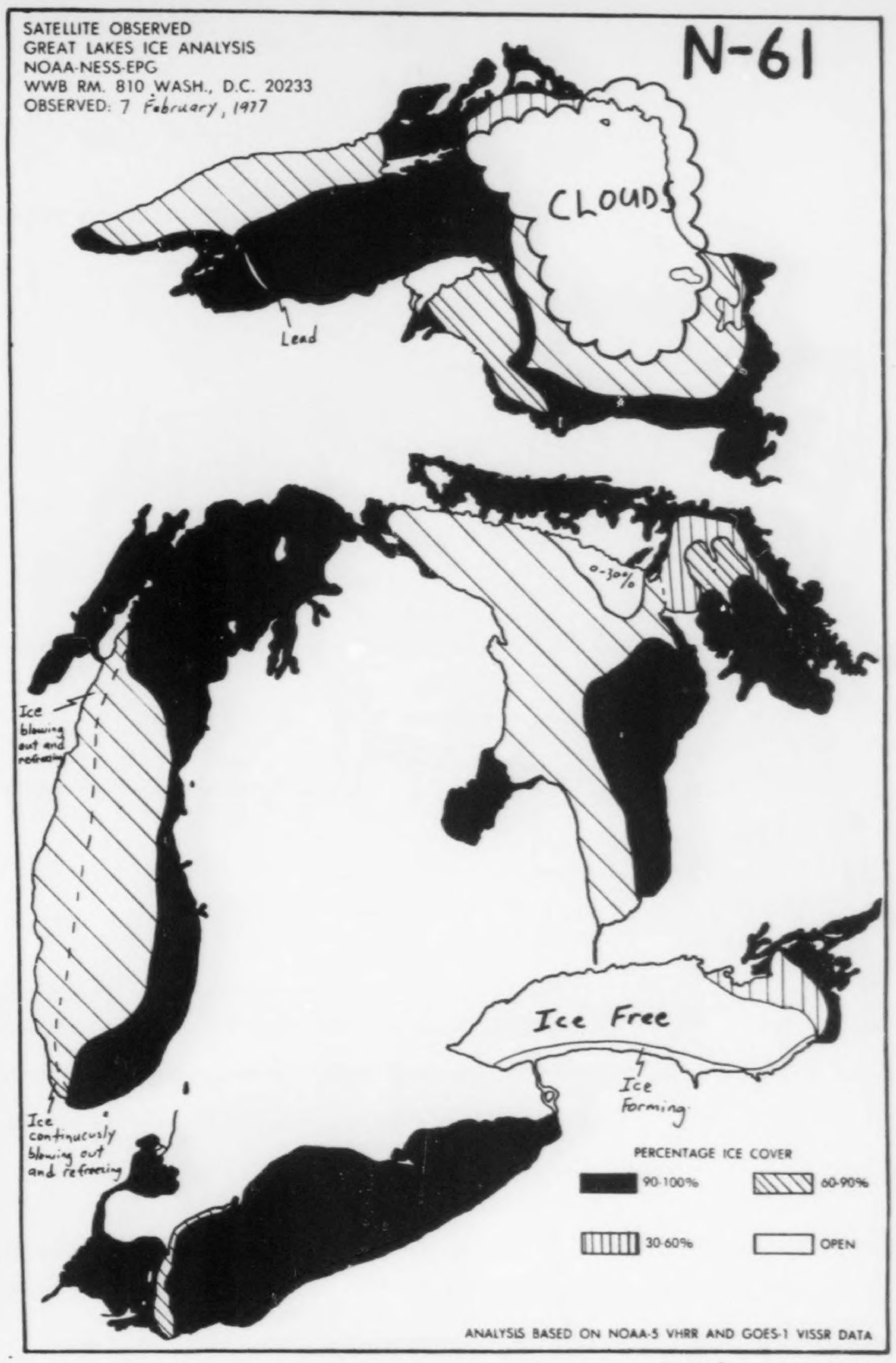
Altogether, 27 U.S. civilian communications satellites are active today.

Landsat for the World

The former NASA Administrator, Dr. James C. Fletcher, once said that if he could have only one satellite, he would choose Landsat. Two of them are in polar orbit. The system is still called experimental; many interests are urging that it be made permanent. Imagery from the Landsat sensors can be computer-treated in so many ways that an enormous variety of information is made available, to suit geologists, farmers, oceanographers, land use planners, environmentalists, geographers, wildlife and range managers, and many more professions. Anyone in the world may buy the images. Who could fear this system? Some new nations fear revelation of their natural resources before they are themselves capable of exploiting the ores, or whatever. (A full feature on Landsat will appear next September.)

Sources of further information, Page 11.

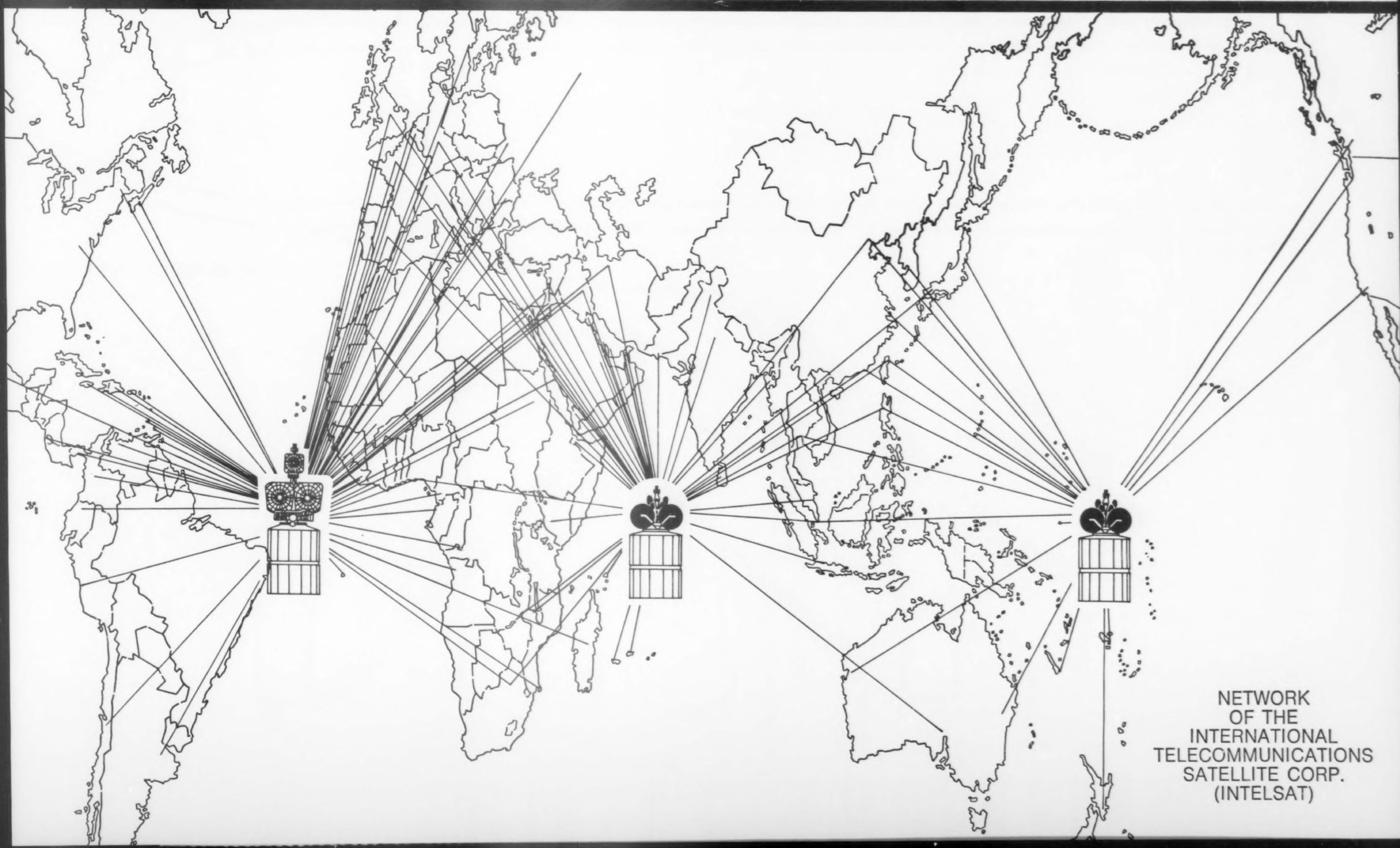

GREAT LAKES ICE INFORMATION SYSTEM
SLAR AIRCRAFT
NOAA GOES-1
UHF UPLINK
VHF DOWNLINK
COAST GUARD ICEBREAKER
S-BAND DOWNLINK
ICE NAVIGATION CENTER (USCG/NWS)
ORE VESSEL
HF-FM
WALLOPS ISLAND STATION (NOAA)


SATELLITE OBSERVED
GREAT LAKES ICE ANALYSIS
NOAA-NESS-EPG
WWB RM. 810 WASH., D.C. 20233
OBSERVED: 7 February, 1977
N-61
CLOUDS
Lead
0-30%
Ice blowing out and refreezing
Ice Free
Ice Forming
Ice continuously blowing out and refreezing
PERCENTAGE ICE COVER
90-100%
60-90%
30-60%
OPEN
ANALYSIS BASED ON NOAA-5 VHRR AND GOES-1 VISSR DATA

7 February 1977

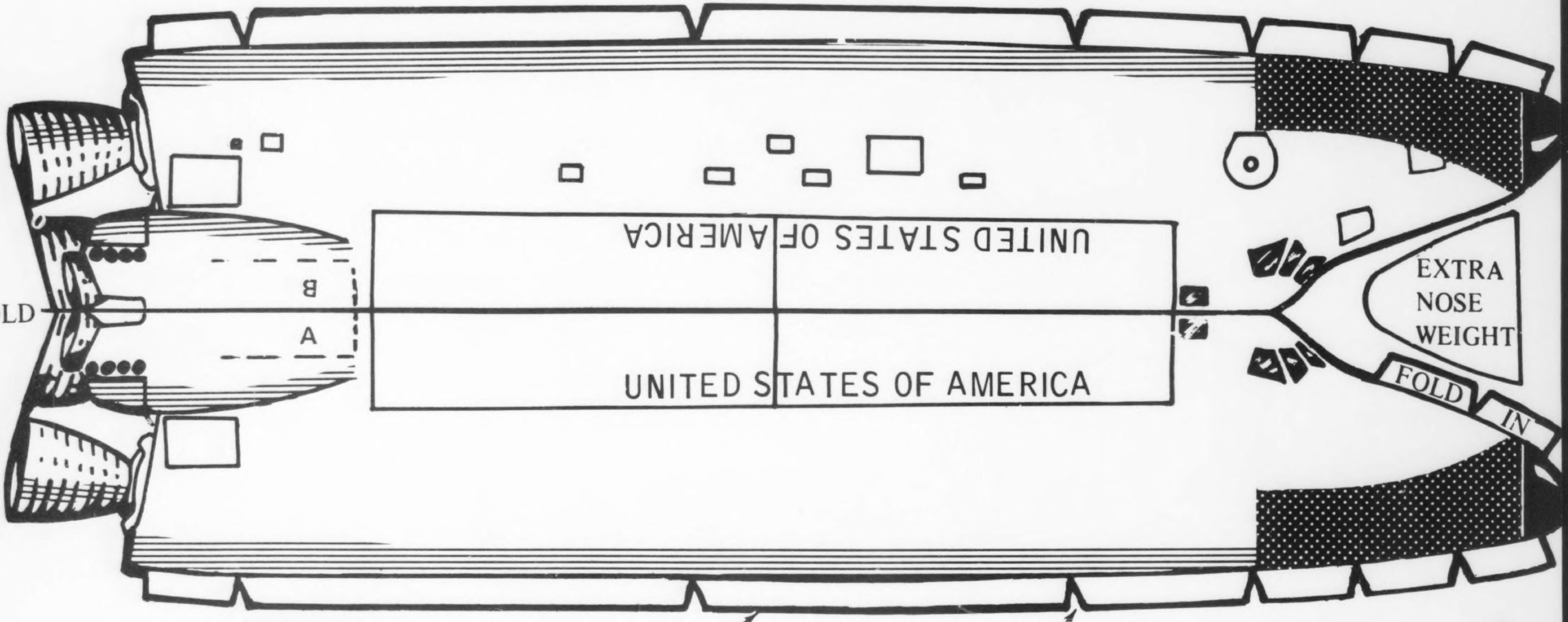
One of the many efforts to keep Great Lakes shipping going in winter is diagrammed above. Side-Looking Airborne Radar (SLAR) images are relayed by the NOAA satellite for processing at a ground station, with further relay by land lines to a Cleveland center which sends them by radio facsimile to ships. In "Project Icewarn," satellite images are converted to clearer line drawings (top right), also radioed to ship captains.

Below, location of INTELSAT communications satellites and receivers. As of November, 1977, 101 telecommunications agencies were operating 141 antennas at 112 stations around the world.



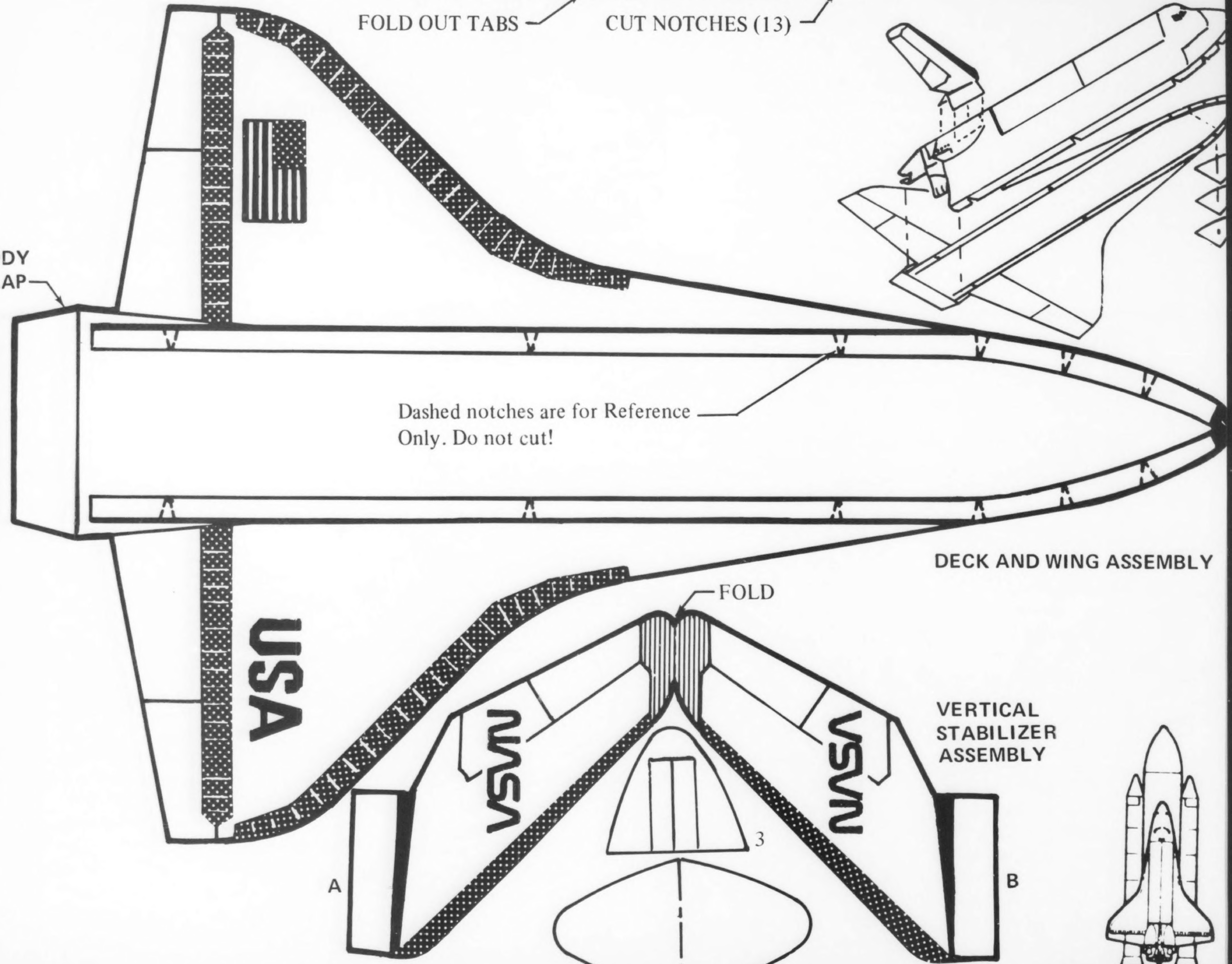
NETWORK
OF THE
INTERNATIONAL
TELECOMMUNICATIONS
SATELLITE CORP.
(INTELSAT)

PHOTOCOPY ON PAPER AS HEAVY AS POSSIBLE


UNITED STATES OF AMERICA
UNITED STATES OF AMERICA
FOLD
B
A
EXTRA NOSE WEIGHT
FOLD IN

FOLD OUT TABS

CUT NOTCHES (13)


BODY FLAP
USA
FOLD
NASA
NASA
A
B
3

Dashed notches are for Reference Only. Do not cut!

DECK AND WING ASSEMBLY

VERTICAL STABILIZER ASSEMBLY

NOSE WEIGHTS

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- ☐ Primary
- ☐ Elementary or middle school
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- ☐ Adult (teachers' college, aerospace workshops, counseling, etc.)
- ☐ Wide range (as in museums)

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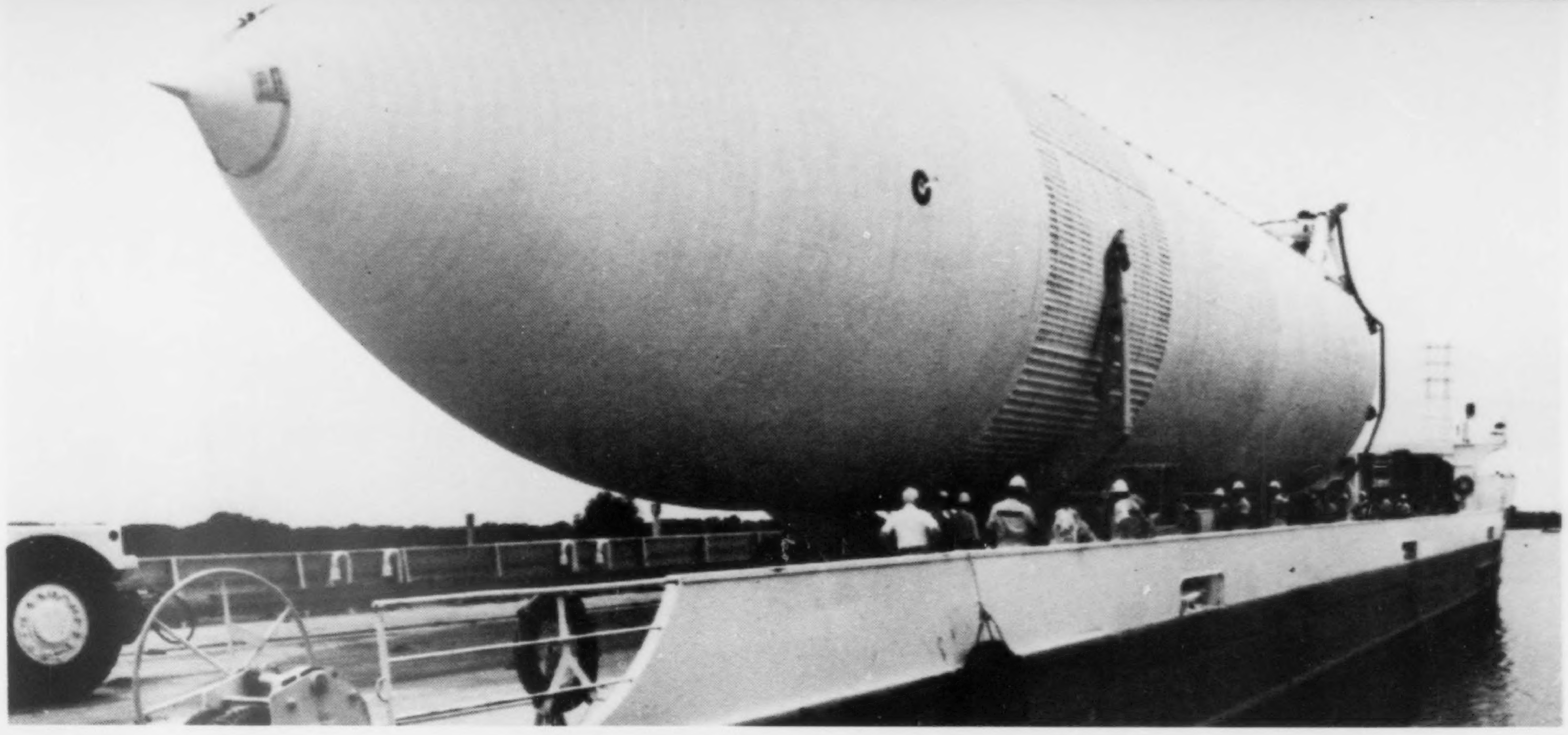


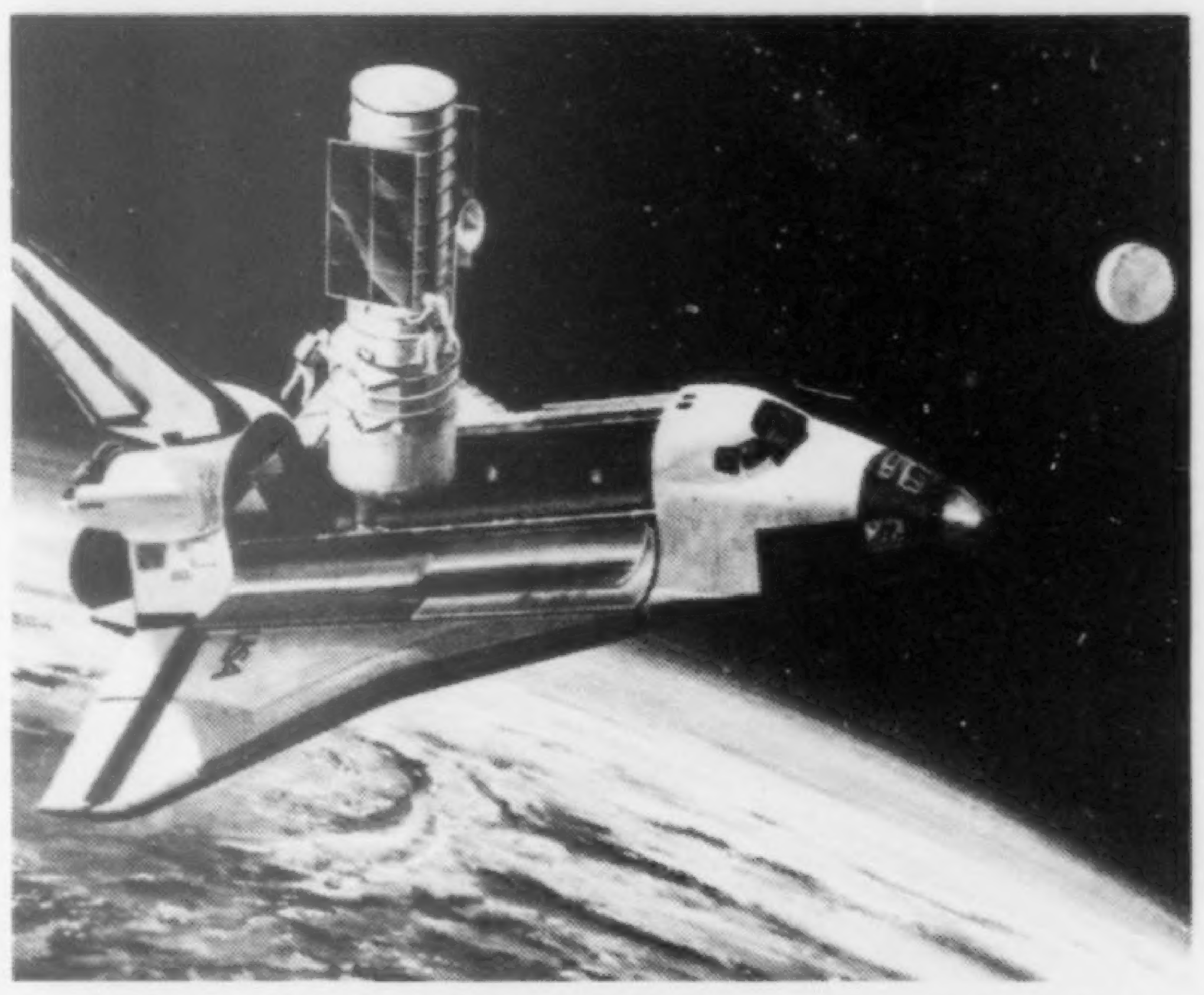
The external tank for the Space Shuttle system, right, travels by barge to a NASA center in Mississippi for static firing tests of the Orbiter's main engines. Below, artist's concept of launch (seagull's view).

Reuseable Shuttle To Open A New Frontier in Space

Since the beginning, every spacecraft has gone up on the flaming thrust of a launch vehicle used only once: propellant tanks, engines, a mass of intricate equipment either drops into the ocean or disintegrates during descent through the atmosphere. The launch vehicle and associated costs have been running $3 to $35 million. Still, over the past 20 years, 12 nations and 3 international groups have paid for approximately 1,800 successful launches.

The waste is well recognized. To reach the Moon on schedule, the U.S. in the 1960s could do no more than push existing technology to its limits with an intensity of effort never before seen outside war. Even then, though, engineers were planning something better, a largely reuseable system. It is called the Space Shuttle, and recently has had top priority at NASA.

In brief, the aircraft-type unit, the Orbiter, contains three engines used only at launch. Liquid fuel is fed in from the large, expendable external tank (shown above). Extra lift comes from two solid fuel boosters which quickly drop into the Atlantic, are recovered by ship, refilled with fuel and reused.



Release of the telescope scheduled for Space Shuttle launch in 1983.

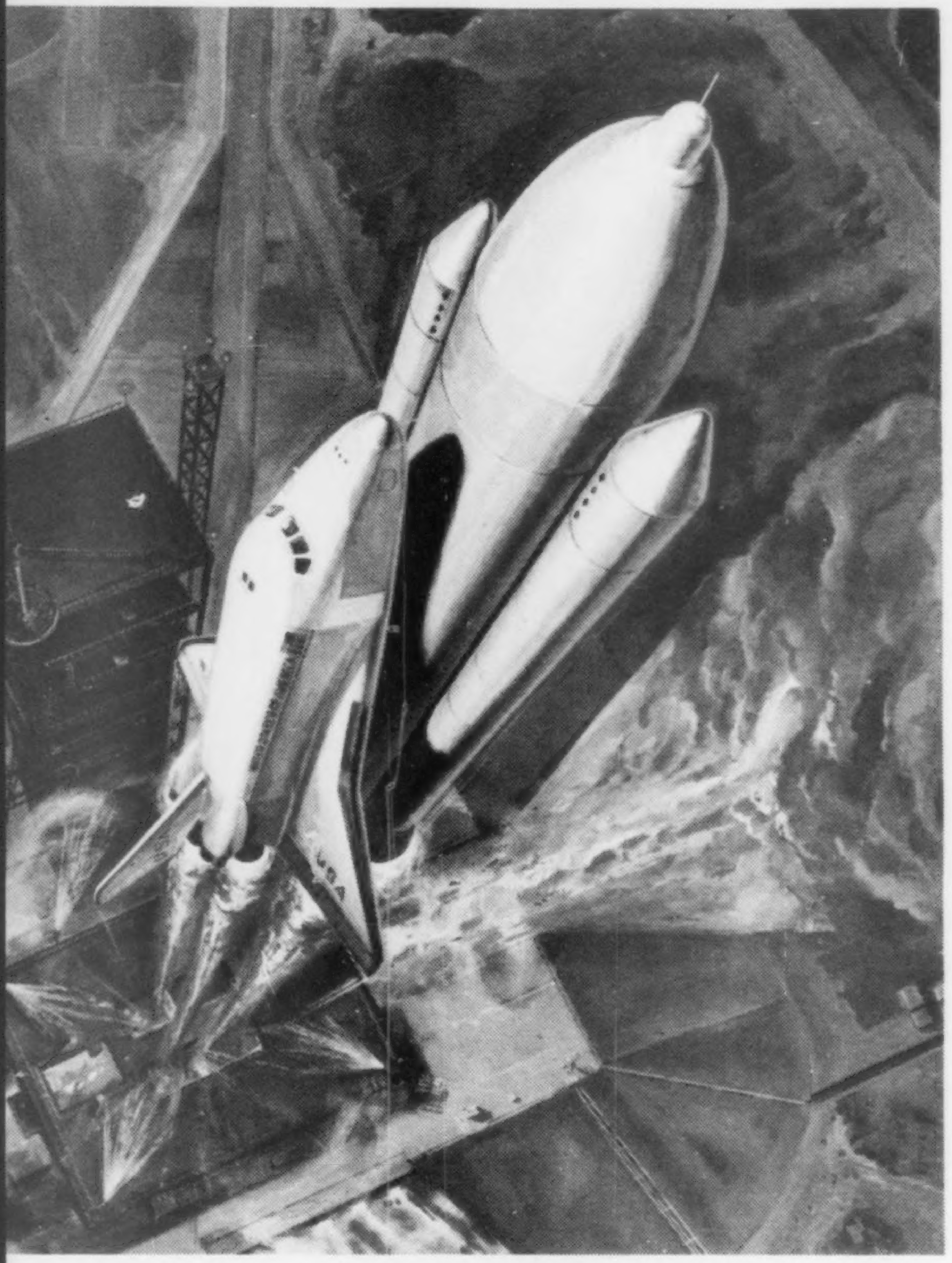
In the top of the Orbiter's fuselage is a payload bay, with large clamshell doors which open in space. The astronauts, using a remote-control manipulator arm, lift out satellite cargo, and also, at times, upper stage engine units which will drive some satellites to higher orbits or toward interplanetary space. The Orbiter itself remains inside the protective Van Allen Belts.

On other missions, equipment for experiments remains in the opened cargo bay, aimed at Earth or the universe.

After a blazing reentry into the atmosphere, the Orbiter's aerodynamic shape enables it to land like a glider. In about two weeks, the Orbiter can be refitted for another trip to space.

The cost to launch a small-scale, self-contained experiment drops as low as $3,000 for a "Getaway Special." More than 170 oddly assorted business and educational interests have already bought such opportunities to try out the space environment. Processing experiments on Skylab and Apollo-Soyuz missions showed how differently materials behave in weightlessness. Freedom from gravity can be achieved for only a few minutes at a time down here. Many scientists are eager to watch chemical, physical and biological experiments over long periods in space. If corporations discover some competitive advantage, they may begin to think about establishing permanent factories in space.

For free literature on the Space Shuttle system, teachers may write to NASA Johnson Space Center, Mail Code JM-61, Houston, Texas 77058.



TO ASSEMBLE THE MODEL:

Photocopy the opposite page on paper as heavy as the copier will take.

1. Cut out all parts, including the notches on the piece at the top, the "fuselage." Fold these tabs out.
2. Glue or tape the nose-weights (one folded, one plain piece at bottom) underneath the nose. Use the fourth one, at top of page, if needed after flight tests.
3. Fold fuselage along middle line.
4. Starting at the nose, glue or tape fuselage to the deck-and-wing piece; match taps precisely to the dotted line areas on the deck.
5. To close the nose, glue or tape the two halves together, using the tabs printed FOLD IN.
6. Fold the vertical stabilizer assembly, bending A and B out. Glue or tape to make one solid piece.
7. Attach vertical stabilizer to fuselage, gluing tabs A and B precisely onto the areas marked A and B near the engines.

Launch with a gentle, level toss. For greater lift, bend the body flap up slightly.

Often All That Separates Science from

A century ago, Jules Verne's tales were considered sheer fiction. Yet many details are now fact, or close.

In the 1940s, it was a science fiction writer, Arthur C. Clarke, who said it would be useful to place an artificial satellite at such an altitude that its orbiting speed would match Earth's rotation.

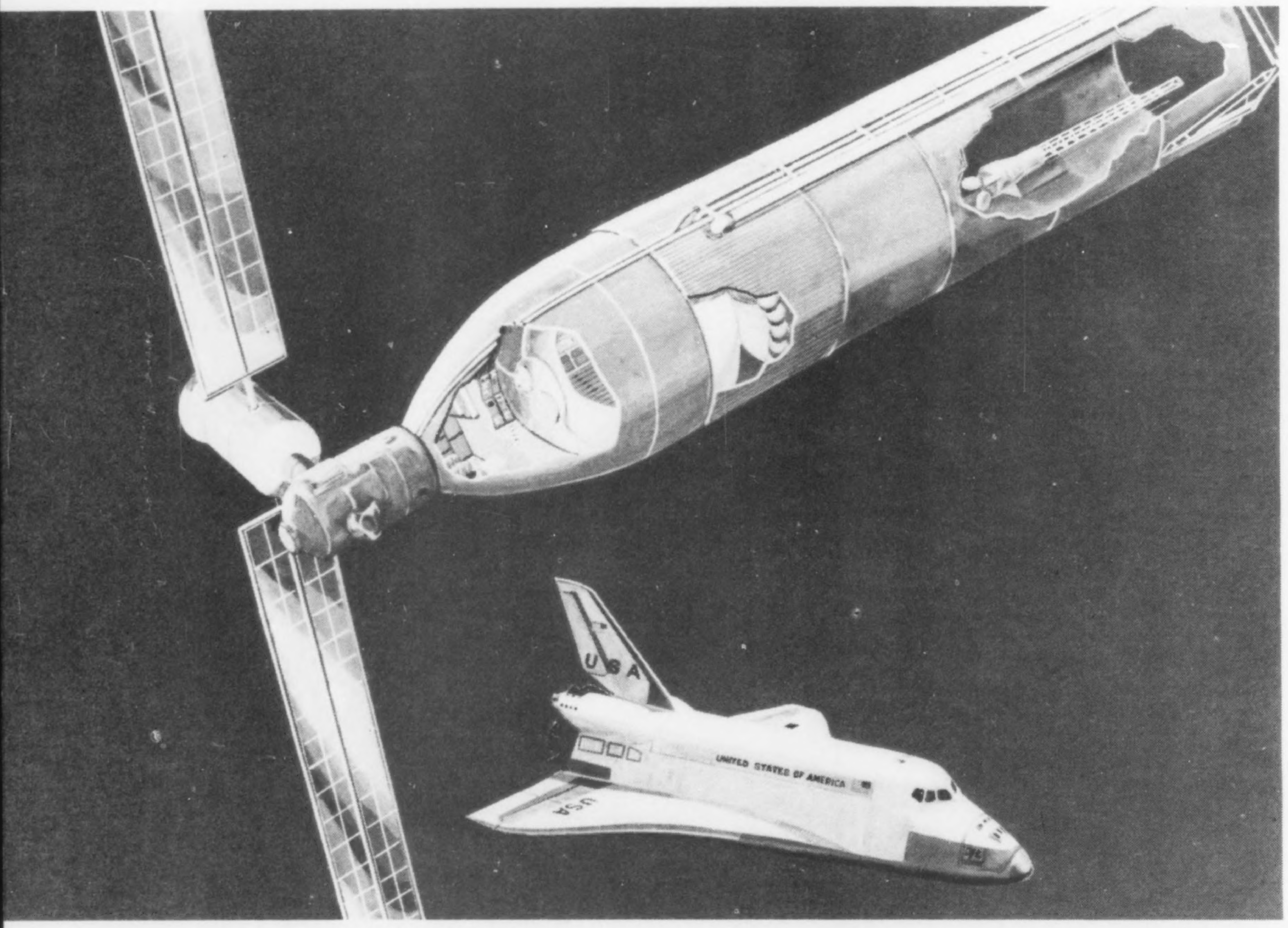
In 1959, how many people would have believed that in a decade, astronauts would walk on the Moon?

Often all that has separated fiction from science is time.

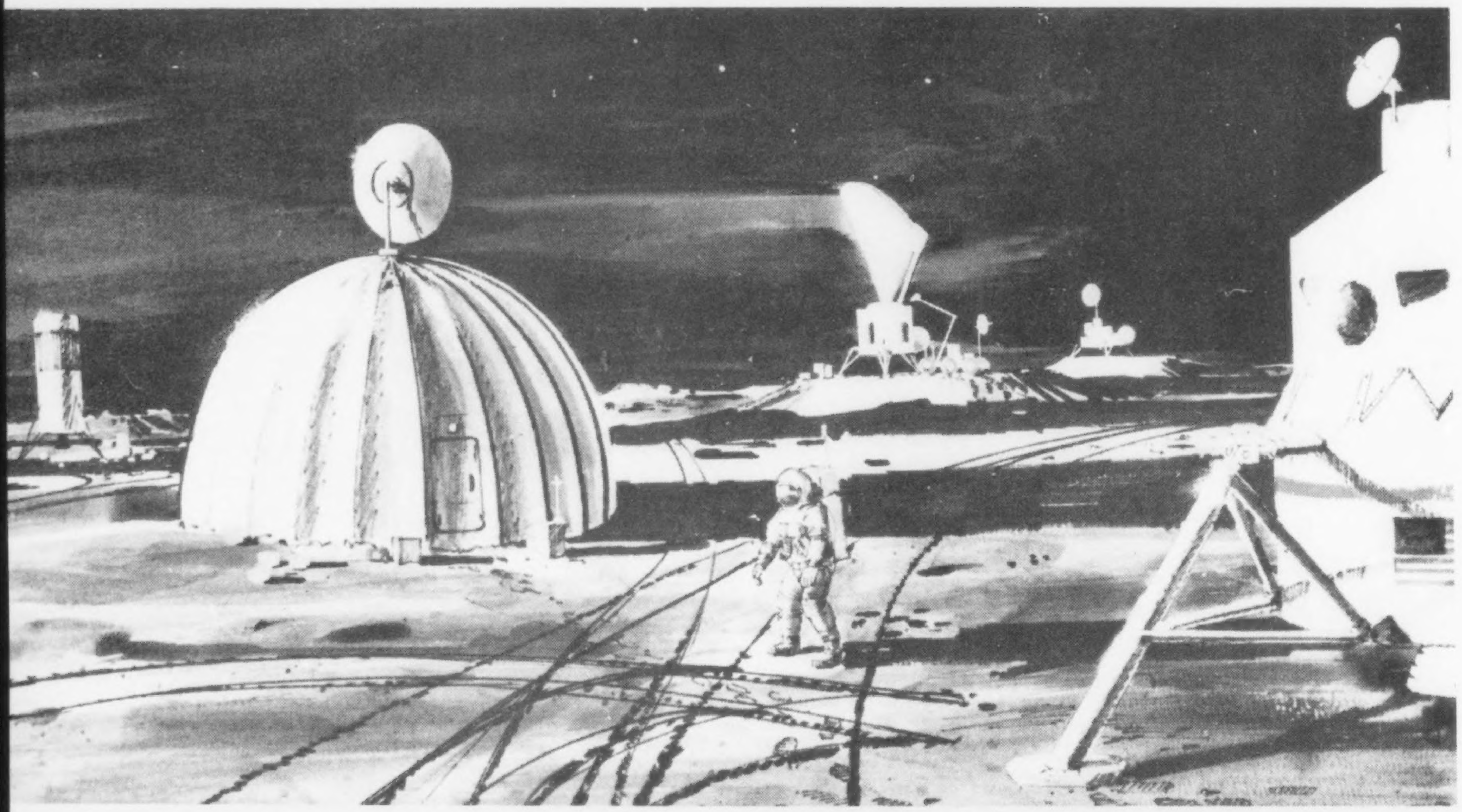
Now, many people are fascinated by proposals to build large space settlements 240,000 miles away, equidistant from Earth and Moon. Respected physicists and engineers draw plans. Others believe that arrangements for space manufacturing could be devised much less expensively at the Moon or nearer Earth. And others think the whole concept is nonsense.

But at the least, discussion stirs the imagination. Sociologists and anthropologists evolve plans for an ideal society in a closed system. They begin to wonder if big, meat-loving, individualistic Americans wouldn't be the

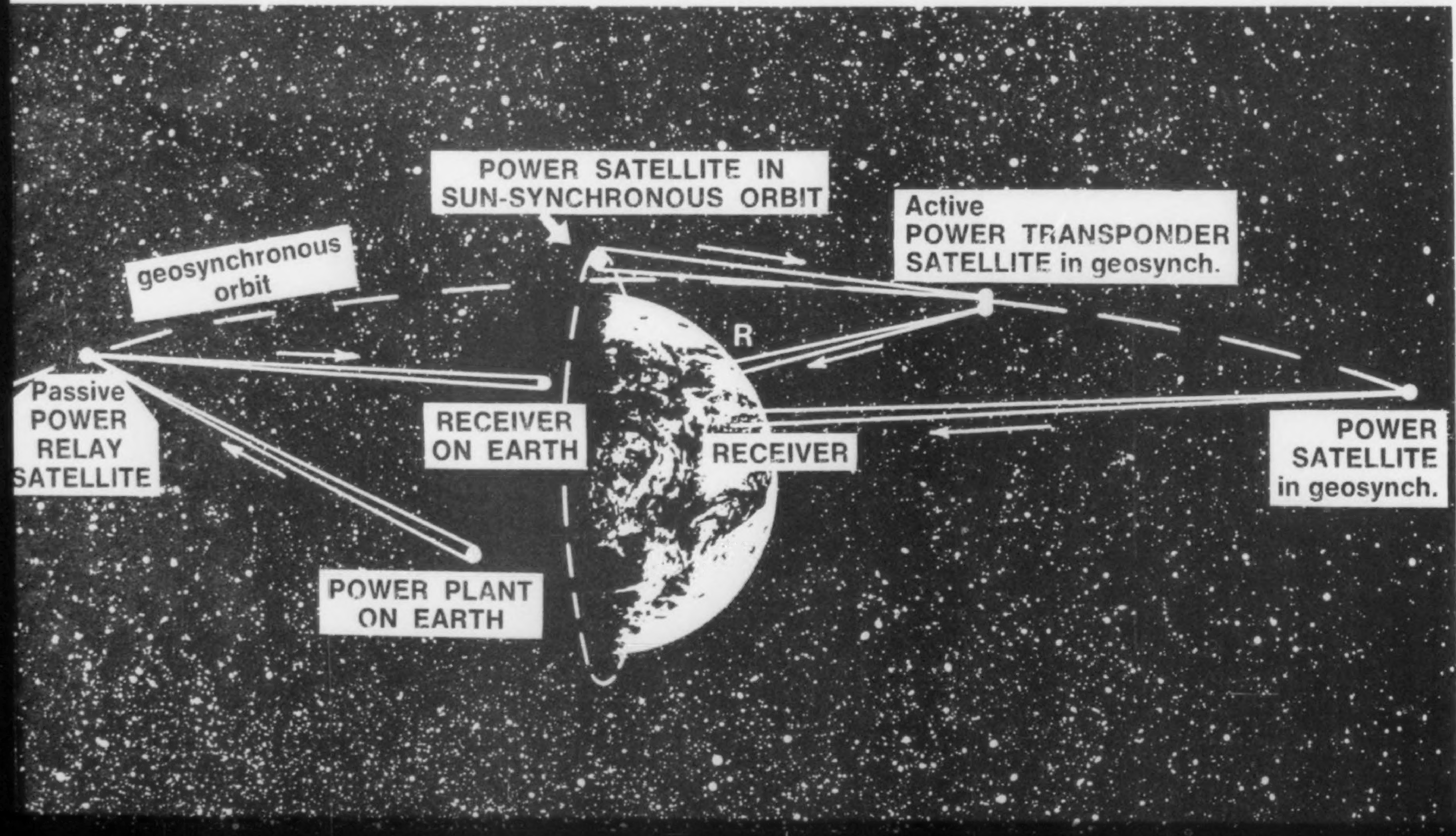
Science or Fiction?


USA
UNITED STATES OF AMERICA
USA

Space station near Earth, serviced by Shuttle Orbiters? Serious planning is underway for a permanent laboratory where scientists can set up long-term experiments. One idea is to adjust Shuttle payloads, carry more fuel, take the external tank on up to orbit, and adapt it for occupation. Solar cells on vertical panels generate electricity.



Moon base? A mining camp would be a major move to begin drawing upon extraterrestrial resources to spare Earth. When cost estimates are made for building large structures in space, as a satellite solar power system, more than half the total cost is for lifting materials from Earth's surface. The Moon offers many useful ores. Moon gravity being one-sixth that of Earth, lift-off would cost less.


POWER SATELLITE IN SUN-SYNCHRONOUS ORBIT
Active POWER TRANSPONDER SATELLITE in geosynch.
geosynchronous orbit
R
Passive POWER RELAY ATELLITE
RECEIVER ON EARTH
RECEIVER
POWER SATELLITE in geosynch.
POWER PLANT ON EARTH

Satellite solar power systems? Three methods for utilizing space are diagrammed at the left: (1) A geostationary satellite passively relays power from one Earth site to another. (2) Several power-generating satellites in low, Sun-synchronous orbit use active power transponders to relay their output steadily to Earth. (3) A geostationary satellite beams power directly to an Earth receiver.

Fiction Is Time—A Decade or a Millenium

worst kind of space colonists. What would be the law, the language, the criteria for selecting colonists? Students wanting to write a paper on this theme could be challenged to think of aspects which physicists and engineers have underplayed so far, notably biological factors. How would they house their space-workmen and shield them from the devastating solar radiation beyond the Van Allen Belts? How would they gauge the percentage of efficient time on the part of workmen? Some astronauts have required hours or a few days to adjust to weightlessness; less rigorously trained construction crews may not be as productive as they are on Earth.

What does the ferment of discussion mean? Dr. T. Stephen Cheston, associate dean of the graduate school, Georgetown University, said in recent Congressional testimony, "Something is up and we don't want to miss out on it." A number of universities are offering credit classes in the evaluation of space industrialization.

Today, the public is drenched with fiction concerning other worlds and interstellar travel. At the same time, a sense of an inevitable, evolutionary spread of Earth life beyond its home planet is expressed by many careful scholars. One, at the National Air and Space Museum, has said:

"An obvious parallel occurred billions of years ago, when sea creatures first emerged onto land, into an alien and nearly lethal new environment. But they evolved lungs. . . and here we are. Now we are sampling another lethal, new environment, with the help of technology.

"Future historians may well look back upon this century, or millenium, and mark it as significant because mankind then took its first tentative steps into space. In time, the human race may spread far, far out. This Sun will die in perhaps four billion years, but life, as we know it, will have gone elsewhere."

Light Speed a Barrier?

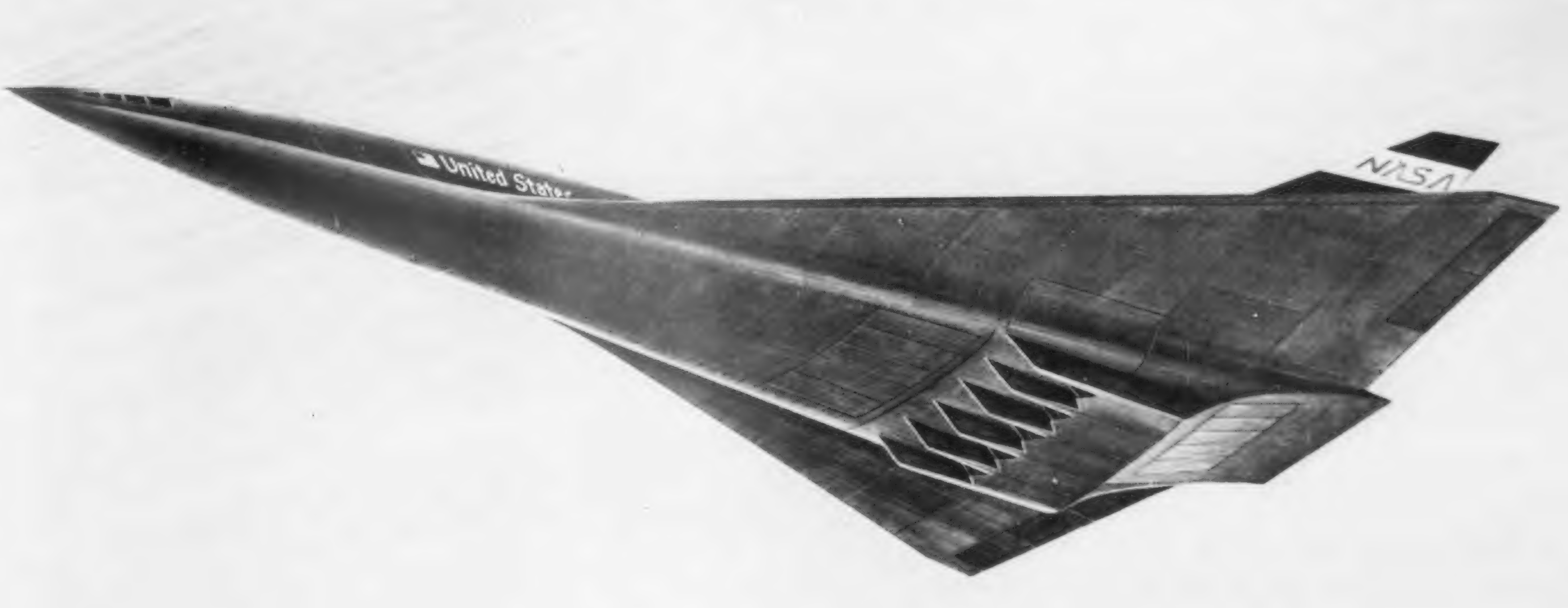
To go, the children of tomorrow may have had to discover what is believed impossible today—how to travel faster than light.

Mel Zisfein, deputy director of the National Air and Space Museum, and an aerodynamicist among other things, has noted a similarity between the way most people today regard "c," the speed of light, and the way many people a generation or so ago regarded "a," the speed of sound. For this publication, he sketched the illustrations which appear on the following page, and drafted the following:

"Some people used to look at the so-called compressibility effect curves and said we'll never fly a winged aircraft faster than the speed of sound. As we increase speed from zero, the forces associated with air pressure, like drag, will rise ever faster and tend toward infinity as we approach the speed of sound, which is a barrier we can't pass.

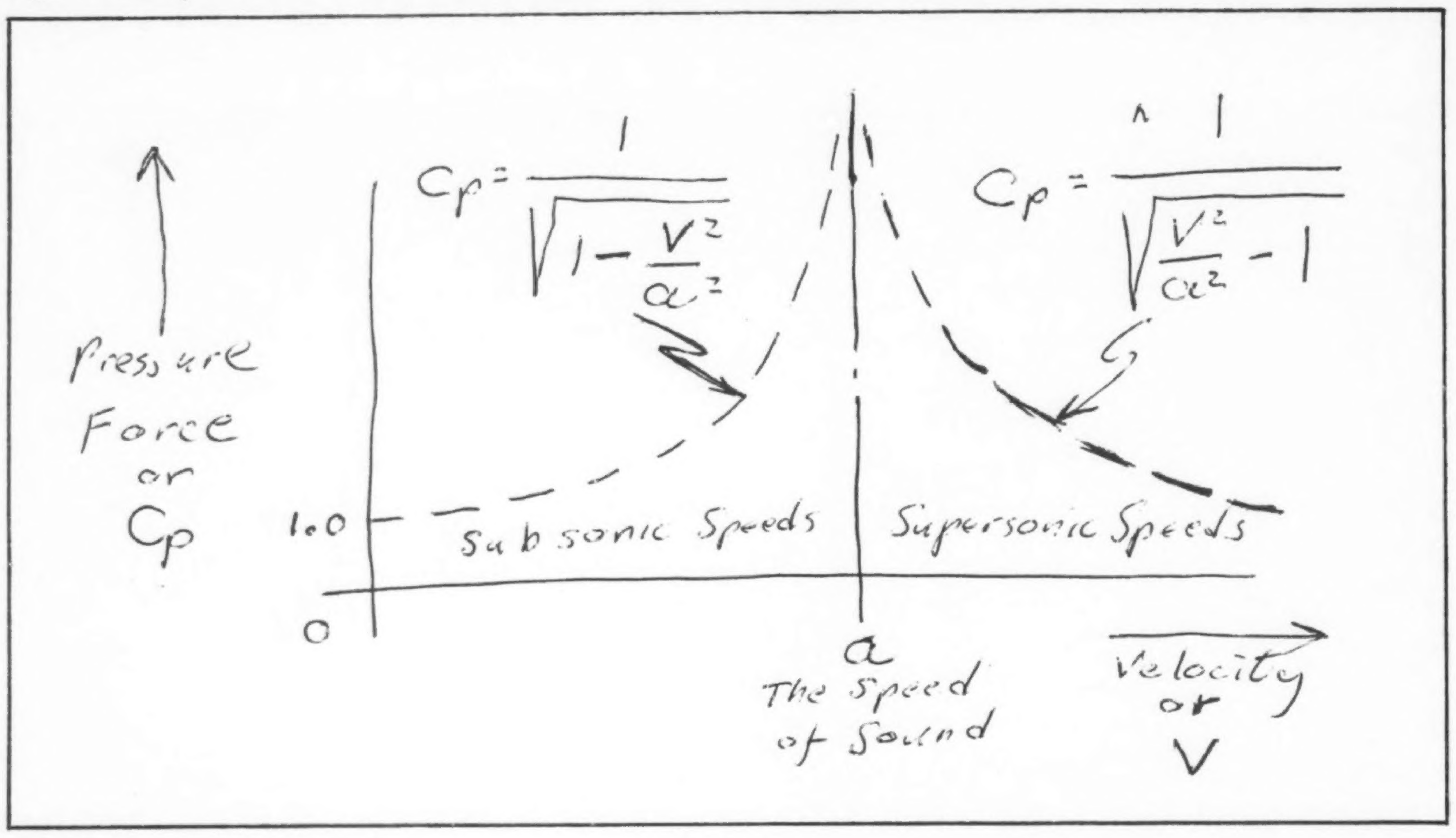
"However, people knew that artillery shells—although not winged aircraft—went faster than the speed of sound, so perhaps there was a chance for airplanes. Subsequently, on October 14, 1947, the Bell X-1 flew supersonically, and today, supersonic flight is an everyday occurrence.

Continued on Next Page



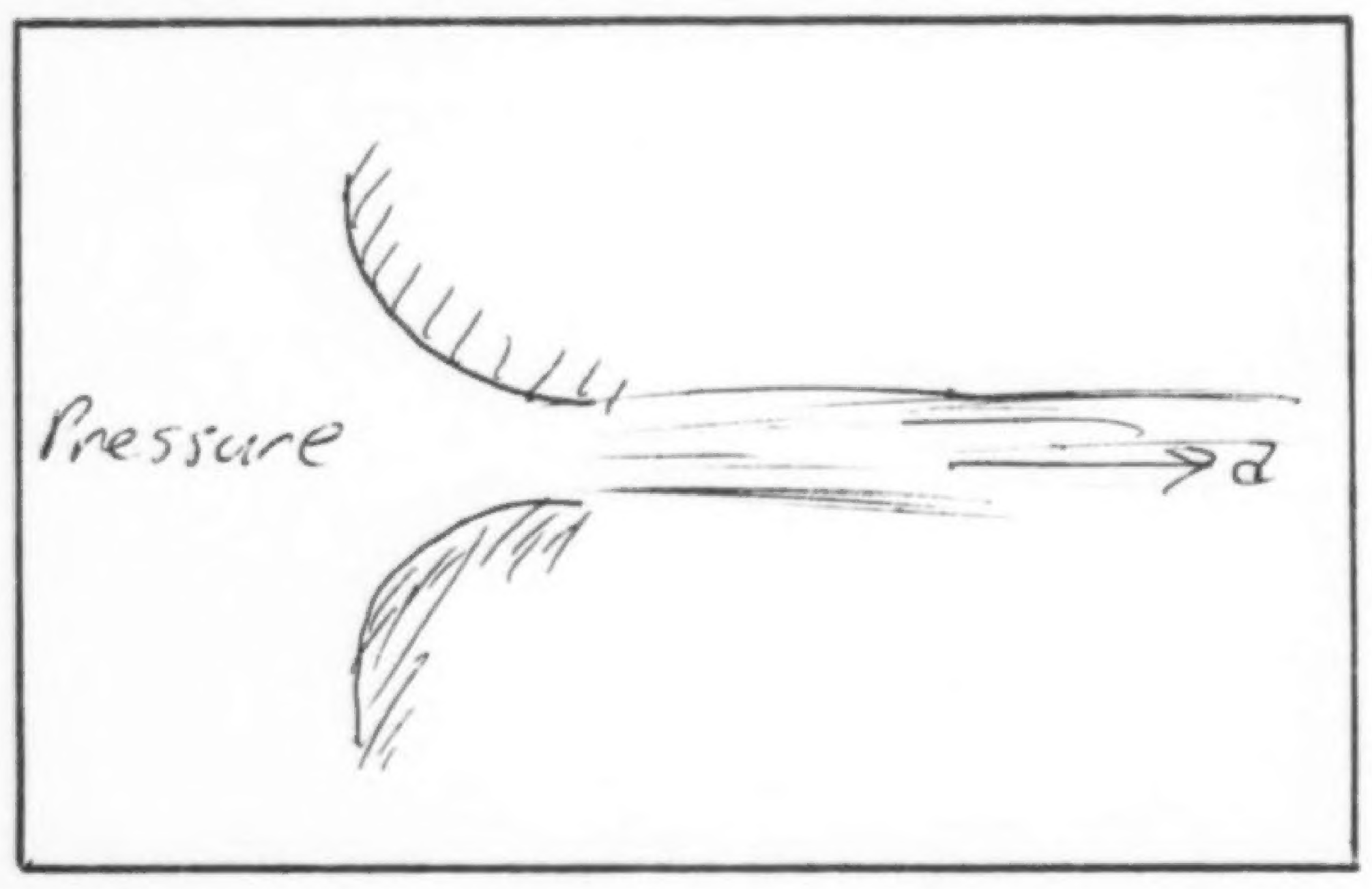
Hypersonic passenger airliner? Los Angeles to Tokyo in two hours, 18 minutes, including subsonic climb and landing approaches? One of the technological advances needed is now under study by Lockheed, on NASA contract. Is it feasible to shift from one system of propulsion to another in flight? Standard turbojets are useful at slower speeds; when acceleration is great enough, can supersonic combustion ramjets (scramjets) take over for cruising at 4,000 mph?

Light Speed a Barrier? *Continued*

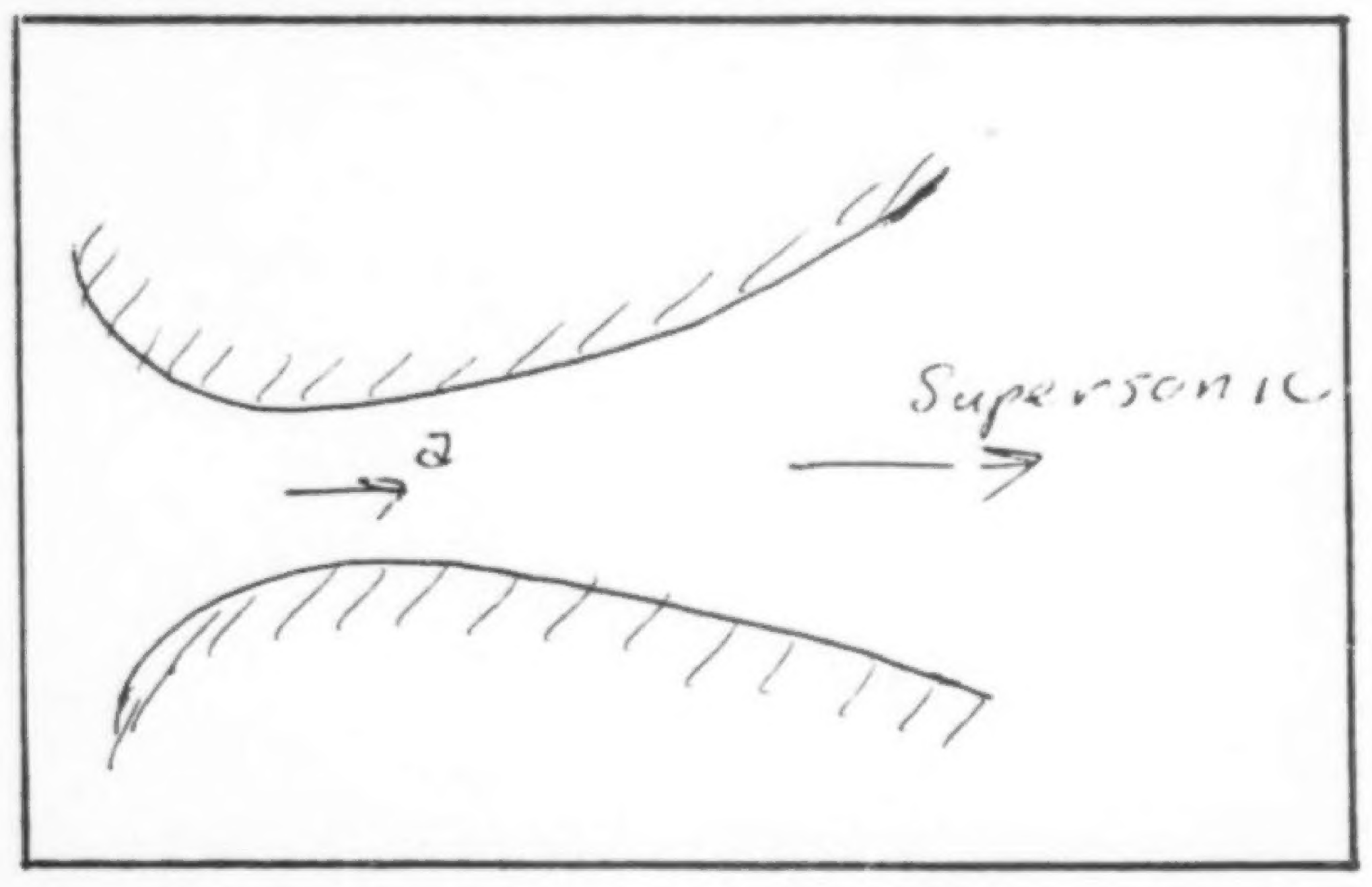


Continued from Page 9

"Earlier, people working with the flow of gases through nozzles had run into a similar manifestation of a 'sound barrier.' When a gas like air was put through a simple nozzle. . .



the speed of sound, 'a,' looked like the highest achievable velocity. The more pressure that was applied across the nozzle, the more energy was dissipated in shocks in the nozzle, leaving the exit velocity no higher than the speed of sound. However the De Laval nozzle was invented. . . .



in which the exit speed could be supersonic.

"Now, some people look at the equations and curves of Einstein's Special Theory of Relativity like the one for mass, 'm' (formula to the right). They notice the similarity in form to the earlier aerodynamic pressure equation and its curve. Some people say we'll never move faster than 'c,' the speed of light. As we increase speed from zero, the mass of any body will rise ever faster and tend toward infinity as we approach the speed of light, which is a barrier we can't pass.

"There is much evidence to support this position. From where we stand today, exceeding the speed of light appears to be a vastly more difficult endeavor than exceeding the speed of sound. Maybe, however, that is only because we haven't figured out how to do it. The basic physical principles involved are vastly different. But I remain fascinated with the mathematical similarities between the pressure equation and curve of the 'sound barrier' and the mass equation and curve of the 'light barrier.' I just wonder if there is some way which we will find some day to enable us to drive particles, and perhaps space vehicles, to speeds faster than 'c'."

Aerospace Periodicals

NASA Report to Educators, quarterly, NASA, Mail Code FE, Washington, DC 20546.

Journal of Aerospace Education, monthly from American Society for Aerospace Education, 821 15th St. NW, Washington, DC 20005, $10 yearly.

Aerospace Education Summer Workshops

A listing of summer aerospace education workshops is prepared annually by the Civil Air Patrol. The 1978 tally will be ready April 15, 1978; queries then may be too late. Few changes occur from year to year; the 1977 list may serve well now and will be sent on request by:

HQ CAP-USAF/EDF
Maxwell Air Force Base
Alabama 36112

Included are 45 workshops in the north central region, 21 in the southeast, 13 in the southwest, 18 around the Great Lakes, 11 in the northeast, 22 in the Rocky Mountains, and 58 on the Pacific side.

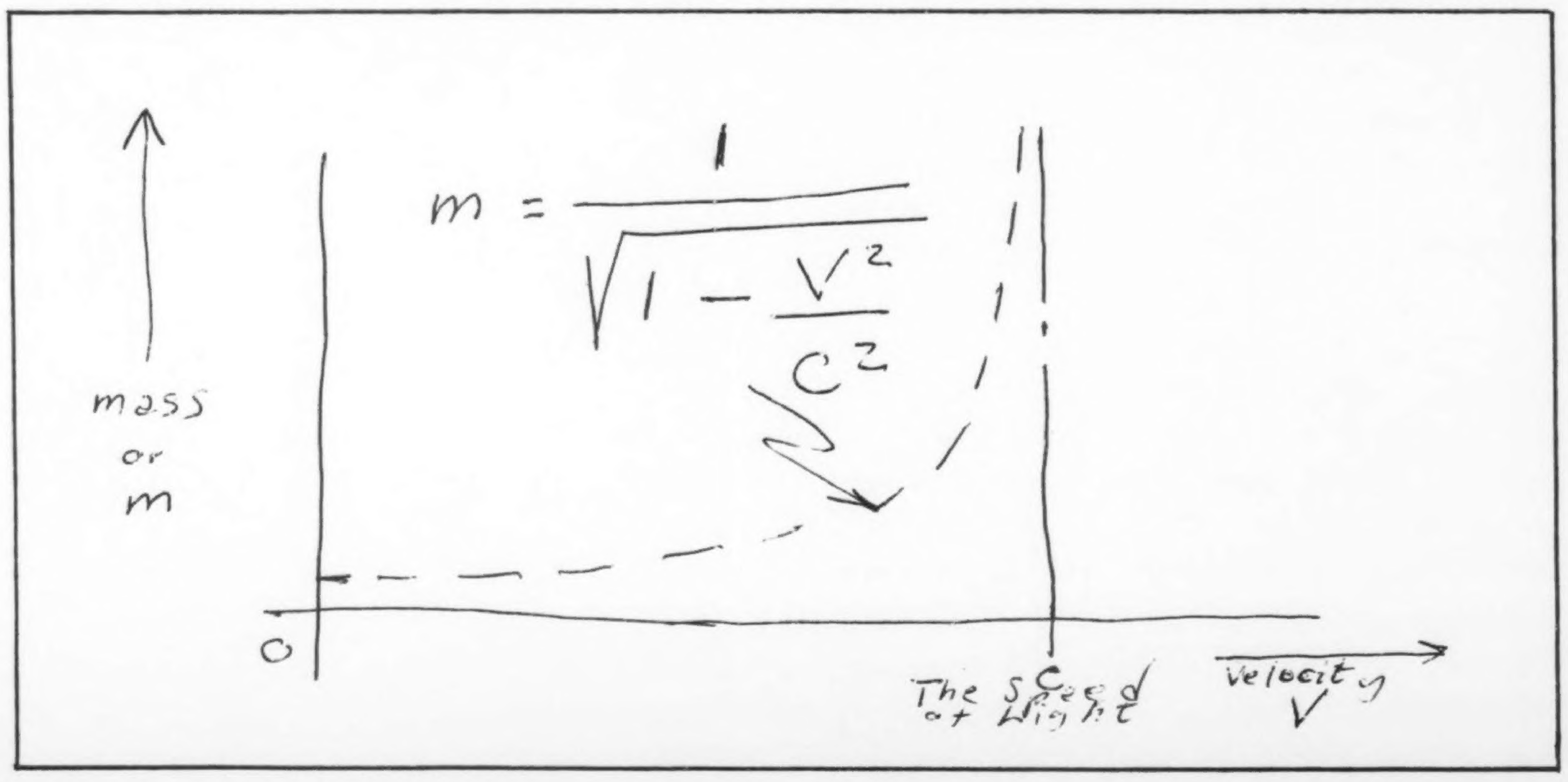
On Aerospace History

Orders of Magnitude, A History of NACA and NASA, 1915–1976, Frank W. Anderson, Jr.; paperback, 6 by 9 in., 100 pp., illus., bibliography. Government Printing Office, Washington, DC 20402, 1976, NASA SP-4403, Stock No. 033-000-00642-0, $2.20

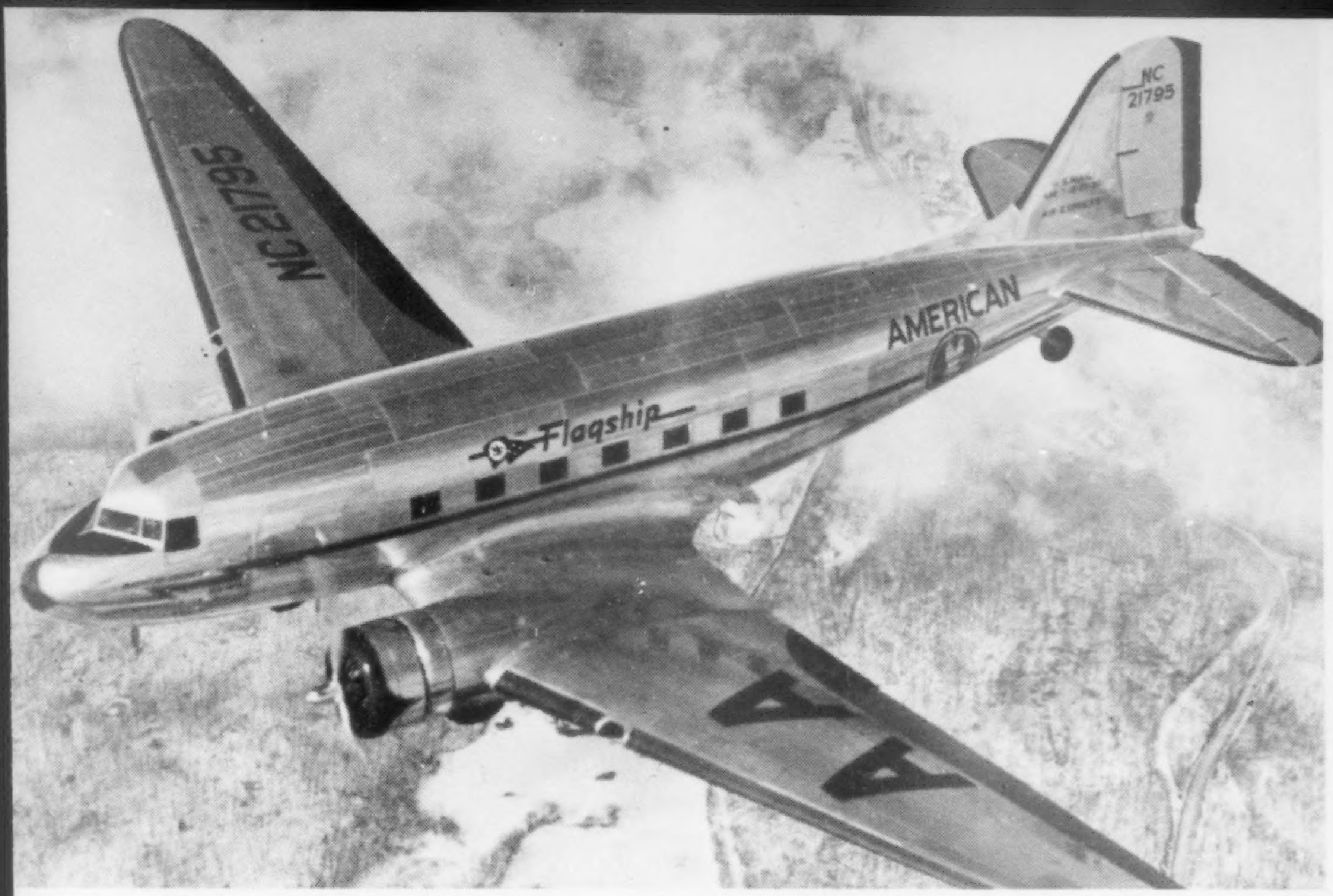
History of Rocketry & Space Travel, Wernher von Braun and Frederick I. Ordway III, 9 by 11 in., 308 pp., many illus., including color; index, bibliography. Thomas Y. Crowell Co., New York, 1975, $25. Exhaustive account from ancient times by men most closely associated with developments.

Two Hundred Years of Flight in America, Dr. Eugene M. Emme, editor, nine papers from a NASM Bicentennial program, 320 pp., illus., index. Univelt, Inc., publisher for the American Astronautical Society, San Diego, California 92128, 1977, $25.

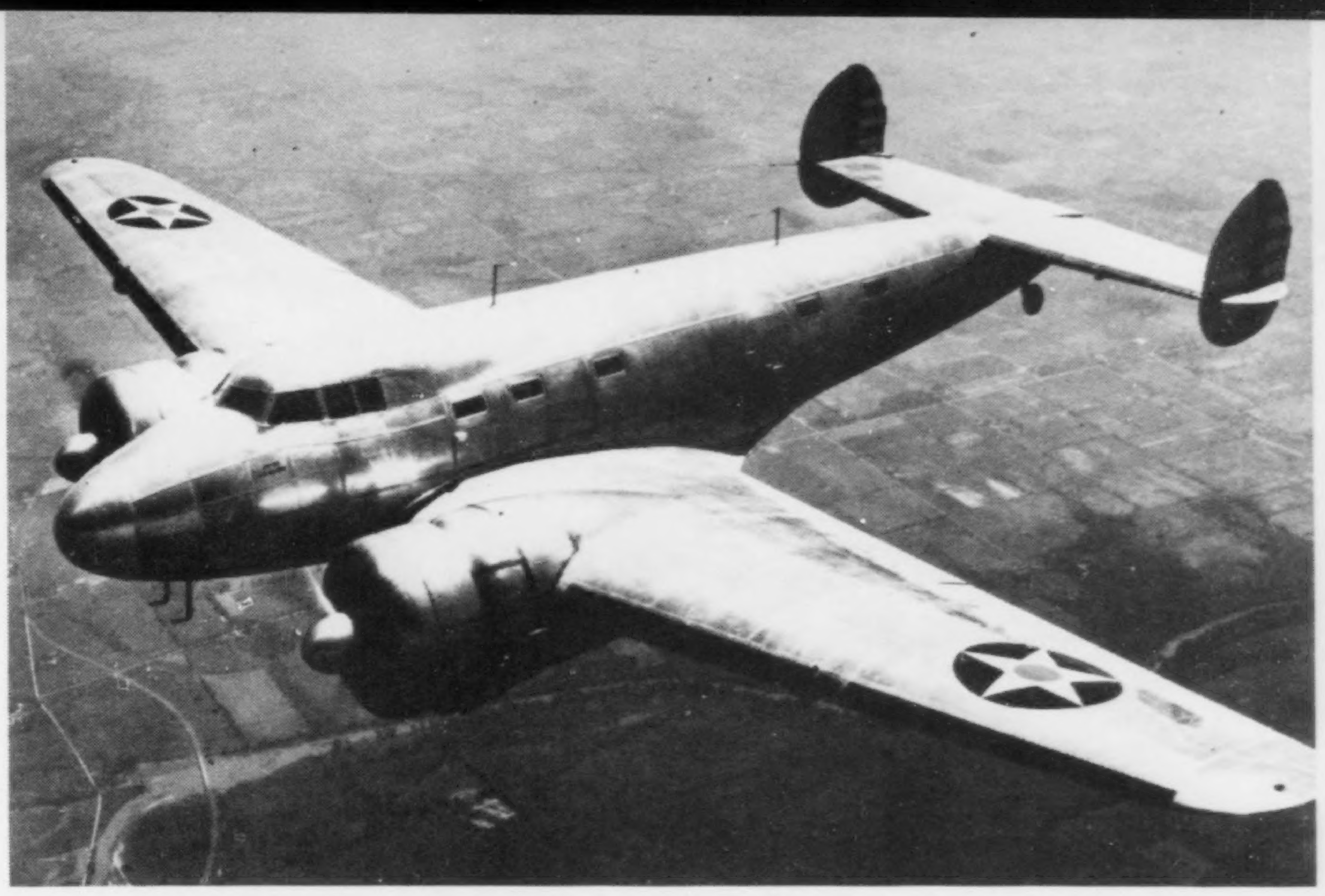
Rockets, Missiles and Men in Space. Willy Ley, long-time associate of von Braun's; 557 pp., illus., index. Viking Press, New York, 1968, $10.95.



Diagrams by Melvin B. Zisfein



DC-3



XC-35

FAMOUS AND OBSCURE PLANES, NO. 1

Aviation buffs may want to start a scrapbook of this feature, which will appear regularly, by members of the Museum's curatorial staff.

By Dr. Richard P. Hallion, Jr.

Assistant Curator
Department of Science and Technology

DOUGLAS DC-3
The Douglas DC-3 is the most famous, historically significant airliner ever built. The DC-3, which first flew on December 17, 1935, was the first airliner capable of making a profit simply by carrying passengers. Until then, airlines had relied heavily on air mail contracts to enable them to make a profit and afford the "luxury" of carrying passengers. The DC-3 entered service with American Airlines in June 1936. It served with many other airlines in the U.S. and abroad, and (in its C-47 military model) with many national Air Forces as well. Eventually, approximately 13,000 were built by Douglas and license manufacturers in the Soviet Union and Japan. The DC-3 is powered—for many are still flying—by two Pratt & Whitney Twin Wasp radial piston engines; it cruises at 178 mph (286 km/hr) and can carry up to 28-32 passengers. A DC-3 is on exhibit at the National Air and Space Museum.

LOCKHEED XC-35
The little-known Lockheed XC-35, which first flew in 1937, was a technology forerunner of modern pressurized aircraft. The XC-35 used air ducted from engine superchargers to provide pressurized air in the passenger cabin. Thus, passengers did not require special oxygen equipment or flight suits even though the XC-35 often operated at altitudes in excess of 10.7 kilometers (35,000 ft). Through flight testing, the XC-35 furnished invaluable information on pressure cabin design and operating characteristics. The XC-35 was a derivative of an earlier Lockheed transport design, and could cruise at 240 mph (386 km/hr). Only one XC-35 was built. It is now in the collection of the National Air and Space Museum.

Reading on Topics in This Issue

Why Man Explores, James Michener, Norman Cousins, Philip Morrison, Jacques Yves Cousteau, Ray Bradbury; 94 pp. Government Printing Office, Washington, DC 20402, 1976, NASA EP-123, Stock No. 003-000-00672-1, $1.10.

Great Lakes All-Weather Ice Information System, R. J. Schertler et al., brochure, 32 pp., illus., NASA Technical Memo TMX-71815, Lewis Research Center, 21000 Brookpark Road, Cleveland, Ohio 44135. Free from author, Mail Code MS 54-2.

Studying the Earth from Space, Department of the Interior, U.S. Geological Survey. Paper, 6 by 9 in., 24 pp., full color Landsat imagery as used in mapmaking, geology, geography, oceanography, land management, etc. Nontechnical. Government Printing Office, Washington, DC 20402. Stock No. 024-001-02987-1, $1.60.

Photographs of satellite images, full Earth disc, or U.S. portion.
They've Got You Covered, a one-sheet reprint on weather satellites.

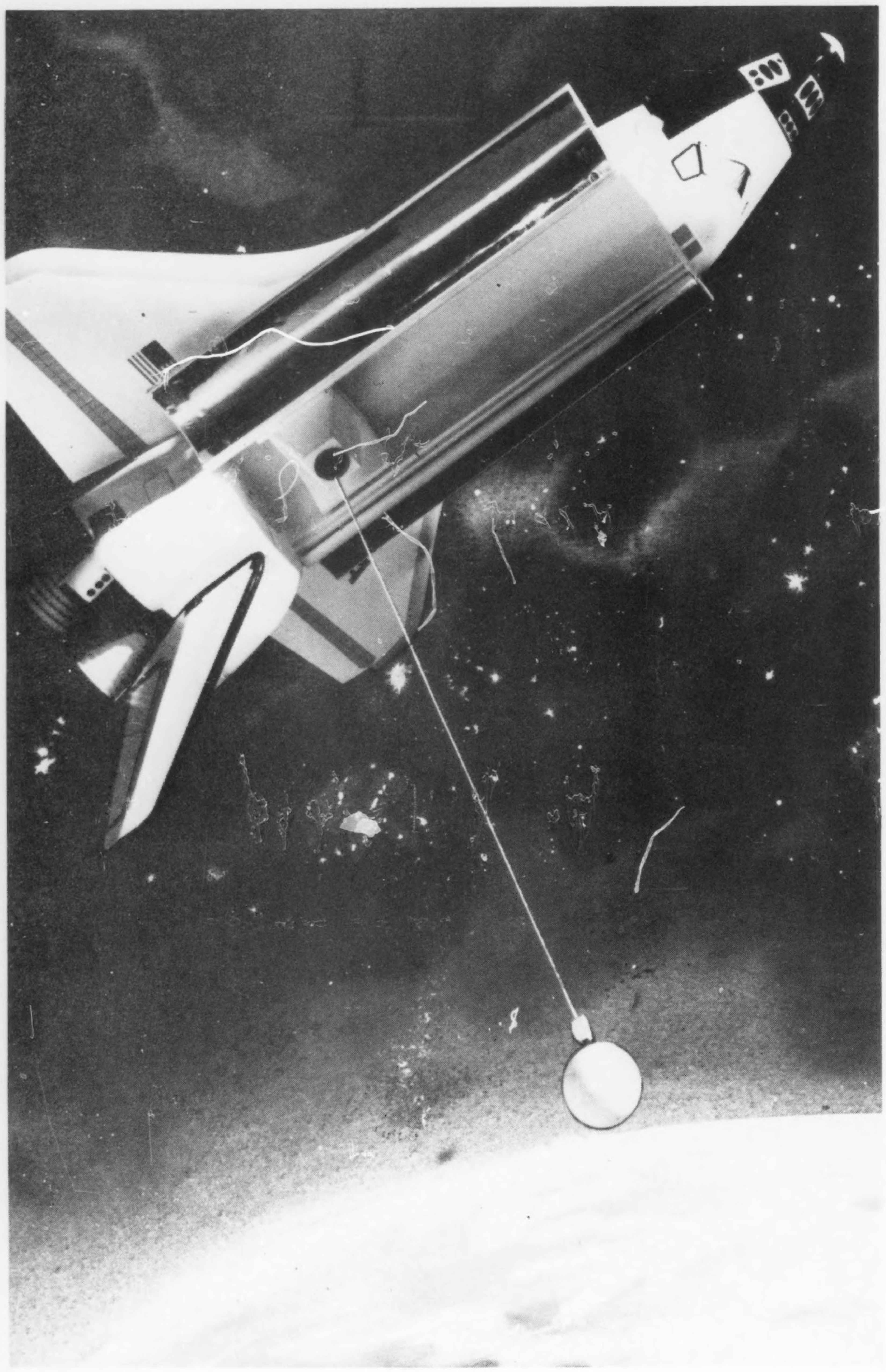
Satellite Activities of NOAA 1977, a brochure, 8 by 10 in., 20 pp., illus. List of all environmental satellites; summary of aeronautical programs and use of satellites in work on weather, search and rescue, lakes and oceans, fisheries, agriculture, Earth, solar and interplanetary physics. All free from Mary Wyvill, Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite Service (NOAA-NESS), Planning and Coordination Group, Washington, DC 20233.

Report to the President and the Congress for Calendar Year 1976, COMSAT, 950 L'Enfant Plaza S.SW, Washington, DC 20024. Free from James McKenna, Public Relations.

Mission to Earth: Landsat Views the World, Nicholas M. Short, Paul D. Lowman, Jr., Stanley C. Freden and William A. Finch, Jr., hard cover, 10½ by 14 in., 459 pp., 400 plates almost all in color as beautiful as impressionist paintings; index, glossary of technical terms, description of Landsat operation. The actual-photography world atlas for libraries. Government Printing Office, Washington, DC 20402, 1976. NASA SP-360, Stock No. 033-000-00659-4, $14.

ILLUSTRATION SOURCES:
Cover: NASM (Wright Flyer, a permanent exhibit); NASA (Earth photographed from Apollo 11 by astronauts Neil Armstrong, Michael Collins and Edwin Aldrin, Jr.) Page 2: NASM. Page 3: Erik Bergaust photo; diagram by Francis A. Bâby and John Clendening, NASM. Page 4: NOAA-NESS. Page 5: NASA Lewis Research Center, NOAA-NESS, and COMSAT. Pages 6,7,8: NASA. Satellite solar power diagram by Dr. Krafft Ehricke when at Rockwell International. Page 9: Lockheed. Page 10: Melvin B. Zisfein. Pages 11 and 12: NASA.

THINK ALONG WITH THE AEROSPACE ENGINEERS



on a current investigation: Uses for a long tether reeled in and out of Orbiters

The artists's drawing to the left is not in proportion. NASA engineers are thinking of a tether as long as 100 kilometers (62 miles).

Engineering for space calls for a new kind of mental agility. The designer anticipates the effects of weightlessness, vacuum, micrometeorites, and sharp differentials of temperature. Further, space is big. This tether concept is on the grand scale. Students may think of other uses besides the one illustrated, which is a project urged by atmospheric scientists. They need more information about the top of Earth's coating of air, the area some 120 kilometers overhead. At that altitude, air is too thin to sustain the flight of an aircraft, yet still can drag a satellite into a flaming reentry. Sounding rockets have carried instruments through the region but the arc of a flight provides only a 10 or 15 minute stay. A typical circular orbit for a Shuttle Orbiter is at 200 kilometers. If instruments were hung on an 80-kilometer-long tether, they could be trolled through the edge of space for days, sampling conditions around the entire globe.

What else? Tethers can become power lines, antennas, communications links, sensors, and cranes, even though the engineers call for a tether only one millimeter in diameter. It would be braided of Kevlar® Aramid yarn, a synthetic stronger than stainless steel.

For a vivid idea of the maximum length of the proposed tether, students can first cut-and-paste the forms given on Page 6. This model is 20 centimeters long. An actual Orbiter is 37 meters long. If a string were attached to the model, simulating the full-length, 100-kilometer tether, how long would the string have to be? (Answer: 540 meters or 1,772 feet, the length of six football fields or 147 12-foot cars bumper to bumper.) Teachers wishing more details may write to the project engineer: Frederick S. Roberts, NASA Headquarters, Code MTG, Washington, DC 20546.

Air & Space, March 1978

NATIONAL AIR AND SPACE MUSEUM
THE SMITHSONIAN INSTITUTION
WASHINGTON, DC 20560

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The Director of the Museum invites suggestions for making *Air & Space* as useful as possible. Some letters may be published; writers should indicate if they prefer that their names not be used.

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